ARMY SCIENCE BOARD

FY2000 SUMMER STUDY

FINAL REPORT

DEPARTMENT OF THE ARMY
ASSISTANT SECRETARY OF THE ARMY
(ACQUISITION, LOGISTICS AND TECHNOLOGY)
WASHINGTON, D.C. 20310-0103

"TECHNICAL AND TACTICAL OPPORTUNITIES FOR REVOLUTIONARY ADVANCES IN RAPIDLY DEPLOYABLE JOINT GROUND FORCES IN THE 2015-2025 ERA"

VOLUME IV
SUPPORT AND SUSTAINMENT PANEL REPORT

Distribution Statement:
Approved for public release; distribution is unlimited

[redacted]

DISCLAIMER

This report is the product of the Army Science Board (ASB). The ASB is an independent, objective advisory group to the Secretary of the Army (SA) and the Chief of Staff, Army (CSA). Statements, opinions, recommendations and/or conclusions contained in this report are those of the 2000 Summer Study Panel on "Technical and Tactical Opportunities for Revolutionary Advancements in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era" and do not necessarily reflect the official position of the United States Army or the Department of Defense (DoD).

CONFLICT OF INTEREST

Conflicts of interest did not become apparent as a result of the Panel's recommendations.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave Blank)

2. REPORT DATE
April 2001

3. REPORT TYPE AND DATES COVERED
Army Science Board – FY2000 Summer Study

4. TITLE AND SUBTITLE
Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era - **Volume IV - Support and Sustainment Panel Report**

5. FUNDING NUMBERS
N/A

6. AUTHOR(S)
Support and Sustainment Panel Chairs:
Mr. Ed Brady, GEN Leon E. Salomon (USA, Ret.), VADM William J. Hancock (USN, Ret.)
Panel Members: Mr. Buddy G. Beck, Mr. Anthony J. Braddock, Dr. David S.C. Chu, Mr. William S. Crowder, Mr. John H. Gully, Dr. Larry Gladney, Dr. Michael Krause, Mr. Ray Leadabrand, Mr. Paul Lumpkin, Dr. Gary R. Nelson, Mr. Donald R. Quartel, Dr. Joseph E. Rowe, Dr. James S. Whang, Dr. Annetta P. Watson

7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(ES)
EXECUTIVE SECRETARY
Army Science Board
SAAL-ASB
2511 Jefferson Davis Highway
Arlington, VA 22202-3911

8. PERFORMING ORGANIZATION REPORT NUMBER
N/A

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

GEN JOHN M. KEANE
VICE CHIEF OF STAFF
UNITED STATES ARMY
201 ARMY PENTAGON
WASHINGTON, DC 20310-0201

GEN JOHN N. ABRAMS
COMMANDING GENERAL
U.S. ARMY TRAINING AND DOCTRINE COMMAND
FORT MONROE, VIRGINIA 23651-5000

GEN JOHN G. COBURN
COMMANDING GENERAL
UNITED STATES ARMY MATERIEL COMMAND
5001 EISENHOWER AVENUE
ALEXANDRIA, VIRGINIA 22333-0001

LTG JOHN COSTELLO
COMMANDING GENERAL
U.S. ARMY SPACE AND MISSILE DEFENSE COMMAND
1941 JEFFERSON DAVIS HIGHWAY, SUITE 900
ARLINGTON, VIRGINIA 22202

MG CHARLES C. CANNON, JR.
ACTING DEPUTY CHIEF OF STAFF FOR LOGISTICS
UNITED STATES ARMY
500 ARMY PENTAGON
WASHINGTON, DC 20310-0500

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
N/A

11. SUPPLEMENTARY NOTES
N/A

12A. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for Public Release; distribution is unlimited

12b. DISTRIBUTION CODE
A

13. ABSTRACT (Maximum 200 words)

The Army Science Board was tasked to seek revolutionary opportunities for improving deployability as well as effectiveness of future joint ground combat forces. The study focused on the possibilities inherent in the Future Combat System(FCS) and also considered enhancements possible through the Future Transport Rotorcraft (FTR). Study efforts were conducted by four major Panels analyzing: Operations, Information Dominance, Sustainment and Support, and Training. The study concludes: 1) the FCS concept is sound, but senior level attention is required to ensure technologies are ready for 2006 FCS EMD; and 2) Key technologies will significantly improve force projection and combat power.

The Support and Sustainment Panel was tasked to: 1) Assess opportunities for reducing the in-theater footprint of support; 2) Assess opportunities to reduce fuel consumption 25% / HP; 3) Assess logistic implications of smart munitions (co-ordinated with Operations Panel); 4) Investigate telemedicine as a means to reduce in-country specialty surgeons; 5) Assess opportunities to improve Near Shore/Logistics-Over-the-Shore operations.

Recommendations include: Establish Ultra-Reliability as an FCS Key Performance Parameter; Use hybrid diesel-electric propulsion for high efficiency; Support DARPA's water-from-exhaust program; Focus on "last 1000 yards" as being more difficult than previous 1000 miles and as required for seamless strategic-to-tactical interface; Strengthen DCSOPS Force Projection capabilities; Establish DCSLOG as the Supply Chain process owner; and Resource a robust logistics C4.

14. SUBJECT TERMS
Support, Sustainment, Supply, Logistics, Ultra-Reliability, Future Combat System, FCS, Exhaust-to-water, water generation and purification, water recovery, Supply Chain, Hybrid Electric, Propulsion, Power, CHPS, Efficiency, battlefield footprint, battlefield support, telemedicine

15. NUMBER OF PAGES
120

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THE PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	None

FY 2000 Summer Study Report Format

The FY 2000 Summer Study has been published in 5 volumes.

- Volume I - Executive Summary
- Volume II - Operations Panel Report
- Volume III - Information Dominance Panel Report
- Volume IV - Support and Sustainment Panel Report
- Volume V - Training Dominance Panel Report

If you received only the Executive Summary, the additional volumes may be reviewed and/or downloaded by visiting

http://www.saalt.army.mil/sard-asb/ and clicking on "Studies."

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era

Support and Sustainment Panel Report

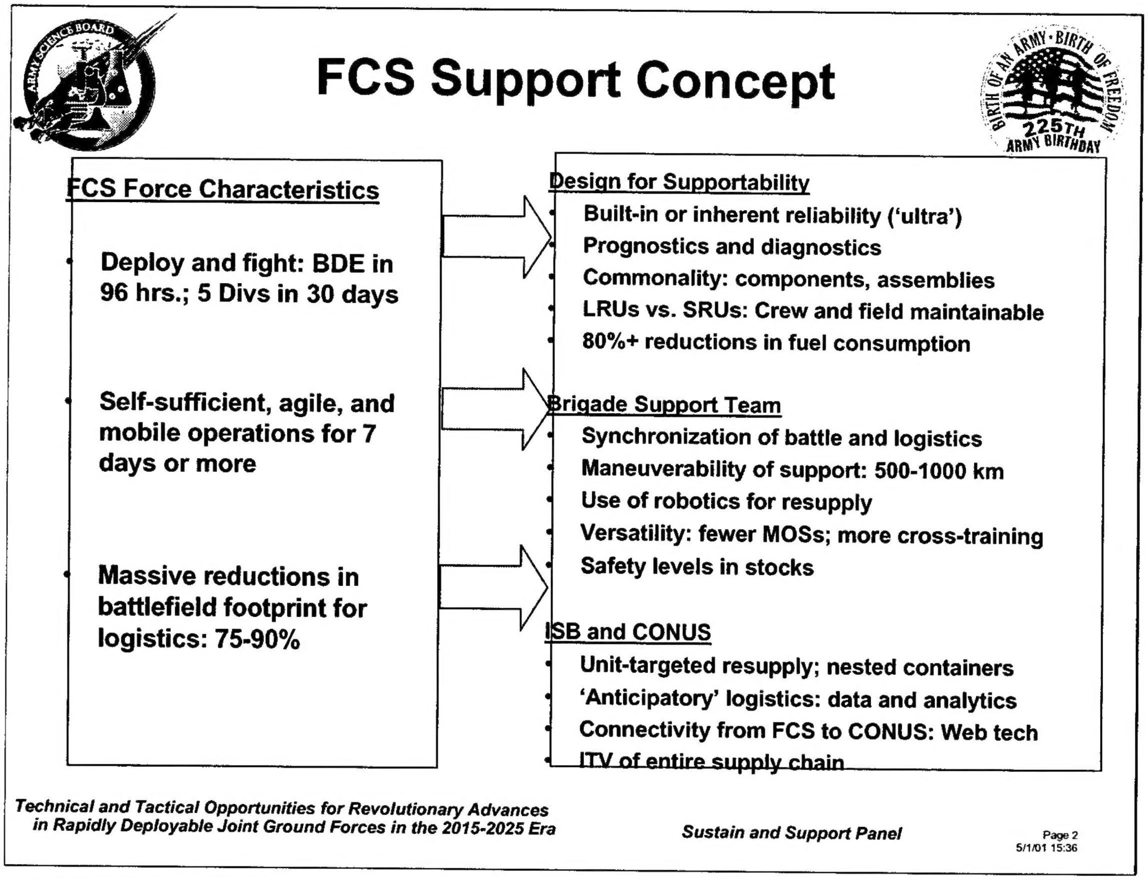
Table of Contents

Support and Sustainment Panel Report		1-61
Appendices		
Appendix A:	Terms of Reference	A-1
Appendix B:	Participants List	B-1
Appendix C:	Acronyms	C-1
Appendix D:	Deployment Subpanel Report	D-1
Appendix E:	Final Report Distribution	E-1

Sustainment

In sustainment, we worked on three problems:

- Development of a support concept as part of the concept of operations for the FCS.
- The reduction in the demand for materiel and support by the FCS.
- Better ways to support the FCS and its soldiers (including medical care) that reduce or even minimize the battlefield footprint for logistics.



The FCS force has far-reaching goals. It must be light and mobile enough to deploy the first brigade in 96 hours and a total of five FCS divisions in 30 days. FCS maneuver units must be self-sufficient for a period of seven days or more. The force itself, to meet deployability and mobility requirements, should have a 75% or more reduction in the battlefield footprint for logistics.

To meet these formidable requirements, we have organized our analysis and proposals around

- the design of the FCS itself
- the support concept on the battlefield
- and the ability to support the FCS force from outside of the theater.

Much of our gain will come from the design and manufacture attributes of the vehicles and systems that constitute the FCS. These include an aggressive program to build an ultra-reliable FCS that will operate for seven days or more without maintenance and support. Supportability will be enhanced through the use of imbedded prognostics and diagnostics systems, use of common parts and components throughout the family of vehicles, modular assembly to emphasize replacement of LRUs rather than repair, and an emphasis on reducing fuel consumption by 80%

The brigade support teams must be as agile and mobile as the maneuver forces themselves. They must be designed to operate with fewer people to provide the full spectrum of support through broadening the training of soldiers and using robotics to carry out resupply operations.

Our battlefield and theater logistics will have a lower profile enabled by the ability to carry out resupply targeted to specific units from outside the theater and using nested containers that carry all the way to the battlefield. This system of 'anticipatory logistics' is driven by models of demand and by information systems and Web portals that extend from CONUS to the maneuver units themselves.

Outline

- Battlefield Fuel, Propulsion, and Power
- Generation of Water
- Reduced Battlefield Footprint
- Ultra-Reliability
- Telemedicine
- Global Strategies for Battlefield Support

We will address each of these topics in turn in determining sustainment for the FCS

Battlefield Power/Propulsion/Efficiency

Fuel, Power, and Propulsion Economies

- **Opportunity**
  - Savings in battlefield fuel consumption of 50-80% are possible through reductions in combat vehicle weight and the use of new power/propulsion technology
- **Discussion**
  - Reduced combat vehicle weight -- the FCS should be about 25% of the M1A2
  - Hybrid electric propulsion systems are more fuel-efficient than mechanical propulsion systems and meet requirements for battlefield electric power
  - The Army can capitalize on large ($Bs) automotive industry investments in hybrid electric technology, but must invest to gain understanding and tailor the technology to meet Army battlefield requirements
  - Advanced diesel engines are important to both hybrid electric and mechanical propulsion systems
  - Fuel cell technology can potentially add to the benefits of hybrid-electric systems, but the conversion of diesel fuel to hydrogen is a challenge today
- **Recommendations**
  - Drive FCS development toward hybrid-electric power/propulsion systems, investing in R&D to tailor commercial technology to meet Army requirements
  - Evaluate cost/benefits of fuel cell technology assuming diesel fuel as the energy source and focus S&T accordingly
  - Investigate the impact of using hybrid-electric propulsion system to provide battlefield power and soldier power (i.e., recharge batteries)
  - Pursue development of a tailored, commercial diesel engine for FCS

Starting Points

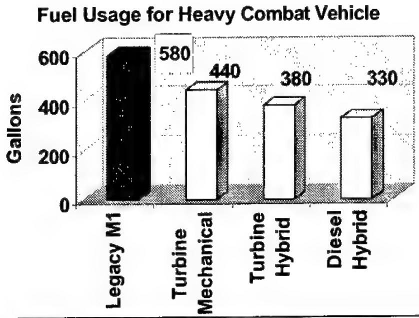
- Fuel is a major sustainment burden for the Army today
- Potential vehicular fuel economies of 50 to 80% offer huge benefits in O&S costs, agility, and reduced logistics footprint
- Reducing vehicle weight is directly related to fuel efficiency (i.e. 70 T ➡ 20 T provides 3.5X improvement)
- Hybrid electric power systems, by improving fuel economy and providing electric power for mobility, battlefield power and recharging of batteries are a simplifying technology, with benefits for support
- Army must leverage commercial power/propulsion developments
  - Substantial industry investment ($Bs) in hybrid electric, fuel cell and diesel engine technology
  - Army investments to focus technology on Army needs
- Diesel fuel will remain the fuel of choice on the future battlefield
  - High energy density and low vulnerability
  - Single fuel supports multiple legacy and objective systems, as well as multi-service requirements
- Environmental considerations growing in importance

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era — *Sustain and Support Panel* — Page 6 5/1/01 15:36

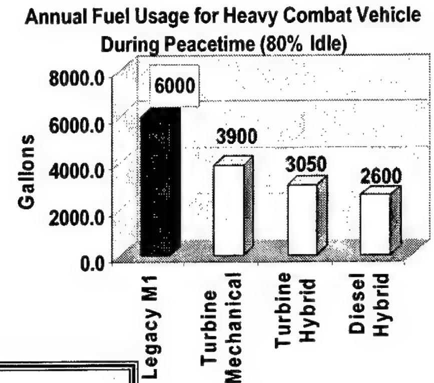
80% of what we move to the battlefield is support and 50-70% of that is diesel fuel. The ASB believes that total battlefield fuel consumption can be reduced by 50% (and up to 80%), which has a tremendous impact on support and sustainment. This is accomplished by significantly reducing vehicle weight and synergistically applying hybrid electric power systems to provide propulsion power for vehicles, battlefield power for weapons, countermeasures and C4ISR, and rapid recharging of batteries to provide robust power for soldier systems. These hybrid electric power systems leverage substantial investments by industry ($Bs) for transportation, utility, and portable electronics. The commercial world is driven to electric power by increased efficiency, increased reliability and decreased emissions. The Army must leverage these developments if it is to afford state-of-the-art, cost-effective, power and propulsion systems supported and upgraded throughout the life cycle by commercial investments.

TACOM Blue Ribbon Committee - Fuel Usage for Heavy Combat Vehicles

24 hr Battlefield Day Fuel Consumption Comparisons



Annual Peacetime Fuel Usage (80% Idle) Comparisons



80% of what we move is support

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era

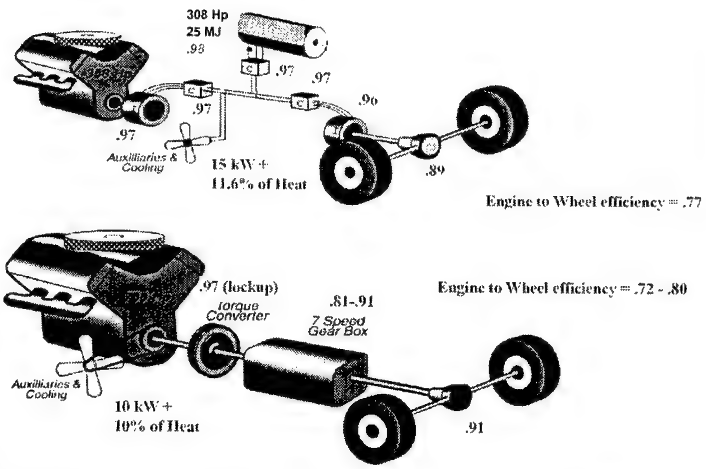
Sustain and Support Panel

Page 7
5/1/01 15:36

Several years ago TACOM established a Blue Ribbon Committee to look at fuel consumption for heavy combat vehicles. The charts show fuel consumption for a legacy M1 compared to an advanced turbine mechanical drive and both a turbine and diesel-based hybrid drive. The chart on the right shows annual peacetime fuel usage, recognizing that 80% of the time the vehicles are idling. Overall, these charts show hybrids having a 25% improvement over state-of-the-art mechanical systems and a 50% improvement over the legacy system.

Mechanical vs. Hybrid Electric Fuel Efficiency

Hybrid and Mechanical Drive Architecture Assumptions



15 Ton Vehicle
50 lb/ton
70 mph max speed
0-60 mph in 20 sec.
60% grade @ 6 mph

Hybrids offer 25- 50% fuel efficiency gain in steady state, transient, and idle operation

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era — *Sustain and Support Panel* — Page 8 5/1/01 15:36

This figure shows the drive architectures and efficiency of components for hybrid and mechanical drives for a 15 ton vehicle and can be used to explain how a hybrid system works. The architectures and efficiencies were used to compare fuel efficiencies for the two systems and show hybrids with a 25-50% improvement in steady state, transient, and idle operation.

Note that for the same vehicle with the same performance, the hybrid has a much smaller engine. In a hybrid, the engine operates at a nearly constant speed to provide the average power for the vehicle; the batteries provide the peak power needed for acceleration and braking. Fuel efficiency gains result from operating the engine at its optimum, reclaiming energy from vehicle momentum by regenerative braking and by turning off the engine and using batteries only for silent watch. Another important impact for the smaller engine is that one can now use a high-performance, commercial diesel engine, modified for FCS, rather than the bigger, heavier Army specific engine required for the mechanical drive.

Capabilities of Hybrid Powered Combat Vehicles (ie. 15T FCS)

- Electrical Power for Battlefield
  (i.e., vehicles, weapons, TOC's, recharge batteries, etc.)
  - 280 kW continuous
  - 5 MW for 2 seconds
  - 4 GW peak pulse burst
  - Recharging batteries for portable devices
- Improved Endurance and Agility
  - 50% fuel savings on engine alone; far greater when combined with reduced vehicle weight
  - 0-60 mph in 15 seconds
- Greater Survivability
  - Reduced signatures
  - Extended Silent Watch (12 hours)
  - Silent mobility (20 miles)
- Design Flexibility
  - Wheel motors - free up under armor volume
  - Wires vs. Shafts-- much greater flexibility

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era *Sustain and Support Panel* Page 9 5/1/01 15:36

The DARPA/Army Combat Hybrid Power Systems (CHPS) Program is developing a hybrid power system for a 15T combat vehicle and demonstrating it in a System Integration Lab. The system uses a commercial diesel engine for a light truck to provide 280kw continuous power, which would propel the vehicle continuously at 60mph, or could power a Tactical Operations Center, or rapidly recharge batteries. The 5 MW for 2 seconds is supplied by a lithium ion battery bank modified for the combat application. This provides robust power to accelerate and maneuver and can power advanced weapons such as high average power lasers or microwaves. The system also supplied a 4 GW pulse of power for electromagnetic armor or an electrothermal chemical (ETC) gun. In addition to the fuel savings and high performance, the hybrid powered combat vehicle should have greater survivability due to reduced signatures. The IR signature from the engine will be smaller due to the smaller, more efficient diesel engine. One can turn off the engine and use the batteries only for up to 12 hours of silent watch or 20 miles of silent mobility.

Finally, there would appear to be significant opportunities to improve the design of the vehicles. If the electric motors can be built directly into the wheels, large under-armor volumes can be made available for other requirements. Replacement of mechanical transmissions and shafts in multi-wheeled vehicles by electrical cables can also free up significant volume and reduce vehicle silhouettes.

Fuel Cells

- For military vehicles, fuel cells offer additional improvements for hybrid electric power systems
  - Fuel cells would replace diesel engine
  - Used in combo with hybrid electric
  - Improves fuel efficiency (Idle to Full Power)
  - Continuous Silent Operation
- Fuel cells could also provide high efficiency electric power for stationary applications or compact power for soldier systems
- Development of a diesel reformer to produce hydrogen for fuel cells is a challenging, DOD specific need
  - Onboard diesel reformer vs. stationary reformers and onboard hydrogen storage
- Combined cycle, solid oxide fuel cells offer significant long-term potential to meet Army power needs
- Concerns about high temperatures

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era — *Sustain and Support Panel* — Page 10 5/1/01 15:36

Fuel cells are an emerging technology that, if successful, would improve performance and could be used to upgrade (P3I) diesel electric hybrid power systems for future combat vehicles. Fuel cells generate electricity from an electrochemical reaction, but unlike batteries, they are continuously fed fuel--typically hydrogen. Fuel cells would replace the diesel-generator in a hybrid system, providing improved fuel efficiency and continuous silent operation. Because fuel cells generate electricity, they must be coupled to an electric drive for propulsion. They are between 20% and 40% more efficient than diesels. However, they are currently much larger than diesels, presenting a significant challenge for integration into a combat vehicle.

Because of the power density issue, the best near-term application for fuel cells on the battlefield is to provide high efficiency, quiet stationary power. The key technical issue with fuel cells for Army applications is how to supply hydrogen fuel for the fuel cell. Reforming diesel fuel to make hydrogen in a compact system is a challenging, DoD-specific need. Commercial systems reform methanol and developmental work is underway to reform gasoline. However, diesel fuel is significantly more difficult to reform because of high sulfur content and there is limited developmental work on diesel reformers. One can either attempt to reform the diesel onboard the vehicle or have stationary reformers generatehydrogen, which is then stored in containers and supplied to the vehicle. Hydrogen storage is much less energy-dense than diesel fuel.

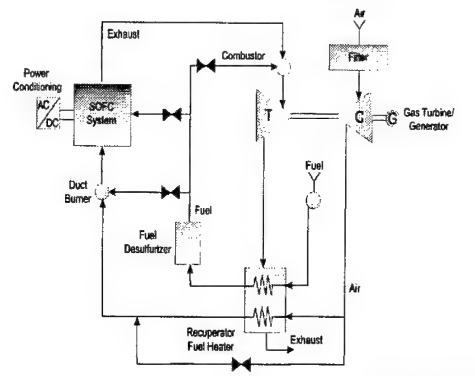
Another application for fuel cells is soldier power. Because of the limited quantities of fuel required for soldier power, it is suggested that either methanol or hydrogen fuel could be used and supplied as a packaged item. Because the energy density of fuel is much higher than the energy density of batteries, fuel cells offer longer operating times. Logistics and safety issues must be addressed.

A technology with significant long-term potential to meet Army electric power needs is a combined cycle solid oxide fuel cell (SOFC). Combined cycle, SOFC address key issues for Army applications of fuel cells, including heat rejection and utilizing diesel fuel. However, the technology is immature and will take years to develop and demonstrate.

Combined Cycle, Solid Oxide Fuel Cell System

- Advantages
  - Excellent integration with simplified reformer
  - Potential efficiency of combined cycle
  - Heat rejection is much easier
    - Promotes high power density propulsion systems
    - Long term military vehicle propulsion candidate
- General Issues
  - Much less mature than PEM
  - Scale up to large vehicle systems
  - Slow startup

Example of Fuel Cell/Turbine Hybrid System



courtesy of Siemens Westinghouse

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era

Sustain and Support Panel

Page 12
5/1/01 15:36

In a combined cycle, SOFC system, a gas turbine/generator and a SOFC work together to generate electricity in a potentially very efficient, power dense configuration. Thermal efficiencies of 60% and as high as 80% are predicted. Both the turbine and SOFC operate at high temperature. Although sulfur in diesel fuel is still a key issue and must be removed in a separate reformation stage, the overall reformation of diesel fuel is simplified because of the higher temperature operation and greater tolerance of impurities.

Although there are many features of the cycle that combine to provide the high efficiency, in essence, one can look at the turbine as a supercharger for the SOFC, providing high volumes of compressed air. This greatly improves the efficiency and power density of the SOFC.

Advanced Diesel Engines

- Advanced diesel engines are applicable to either hybrid or mechanical propulsion systems
- Substantial commercial investment in environmentally friendly, high-speed direct-injected (HSDI) diesels for automotive applications (SUVs, Hybrids)
- Army should not develop an Army-specific diesel engine
- Army needs for higher power density can be achieved by tailoring commercial engines for Army applications

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era *Sustain and Support Panel* Page 13 5/1/01 15:36

Advanced diesel engines provide the Army a prime power source with good efficiency and good power density at an affordable cost. Diesel engines are therefore the most obvious choice as a prime power source for either hybrid electric or mechanical propulsion systems.

Because of the good fuel economy of diesel engines, there is a substantial investment by commercial industry in the U.S., Europe, and Japan to develop advanced, environmentally friendly, high-speed, direct-injected diesel engines for automobiles, sport utility vehicles, trucks and buses.

Rather than developing a customized, Army-specific diesel engine, the Army should tailor commercial diesel engines for Army applications. Army needs for higher power density can be achieved by tailoring commercial engines ie., ceramic inserts, supercharging, or turbo-electric compounding. Although this approach will not produce an engine with the ultimate in-power density, it will result in a compact, affordable, sustainable, efficient engine. Significant investment will be required and is warranted to work with the diesel engine industry to provide this capability.

Conclusions

- REDUCED VEHICLE WEIGHT FOR FCS (75% reduction)

PLUS

- HYBRID ELECTRIC POWER SYSTEMS
  - 25-50% reduction in fuel consumption
  - Battlefield power for weapons, C4ISR, etc.
  - Recharge batteries for robust, soldier power

EQUALS

- MAJOR REDUCTIONS IN SUPPORT
  - 50-80% reduction in battle field fuel consumption
  - Significant reduction in systems/parts (ie. Eliminate stand-alone generator sets and primary batteries)

Recommendations

- Develop a coordinated strategy and accelerate development of hybrid diesel electric power systems for FCS platforms and battlefield power
  - Use Combat Hybrid Power System Test bed and M&S tools to optimize system/controls, develop components, verify performance
  - Use existing Hybrid Electric Platforms (Bradley, HMMWV, 8x8) to demonstrate resulting capabilities
- Evaluate Cost/Benefits of Fuel Cells
  - Focus S&T on Diesel Reformer Development, and combined cycle fuel cells and/or combine cycle SOFC
- Pursue Development of Advanced Diesel Engines for FCS
  - Leverage commercial HSDI Engine development
  - Tailor commercial engines for higher power density, shorter life Army needs

The Army and DARPA are currently pursuing the development of hybrid electric power/propulsion systems in a number of discreet projects. If hybrid electric technology is to be developed and ready for FCS, a strategy for how to coordinate and accelerate the development is required. The Combat Hybrid Power System Test Bed is a significant capability that should be aggressively utilized to gain the requisite understanding and optimization of controls and to verify the performance of components. Multiple tracked and wheeled test beds exist. Resources should be focused on operating and upgrading the test beds (ie., with CHPS technology) as opposed to building new vehicles.

The costs and benefits of fuel cells should be carefully evaluated. Diesel fuel will be the battlefield fuel of the future and the issue of how to reform and supply hydrogen must be addressed. Combined cycle, SOFC offer exciting potential but is an immature technology with significant development required.

Advanced diesel engines offer a good combination of efficiency, power density, and cost effectiveness. The Army should pursue the development of an advanced HSDI diesel engine based on tailoring of a commercial engine.

Generation of Water on the Battlefield

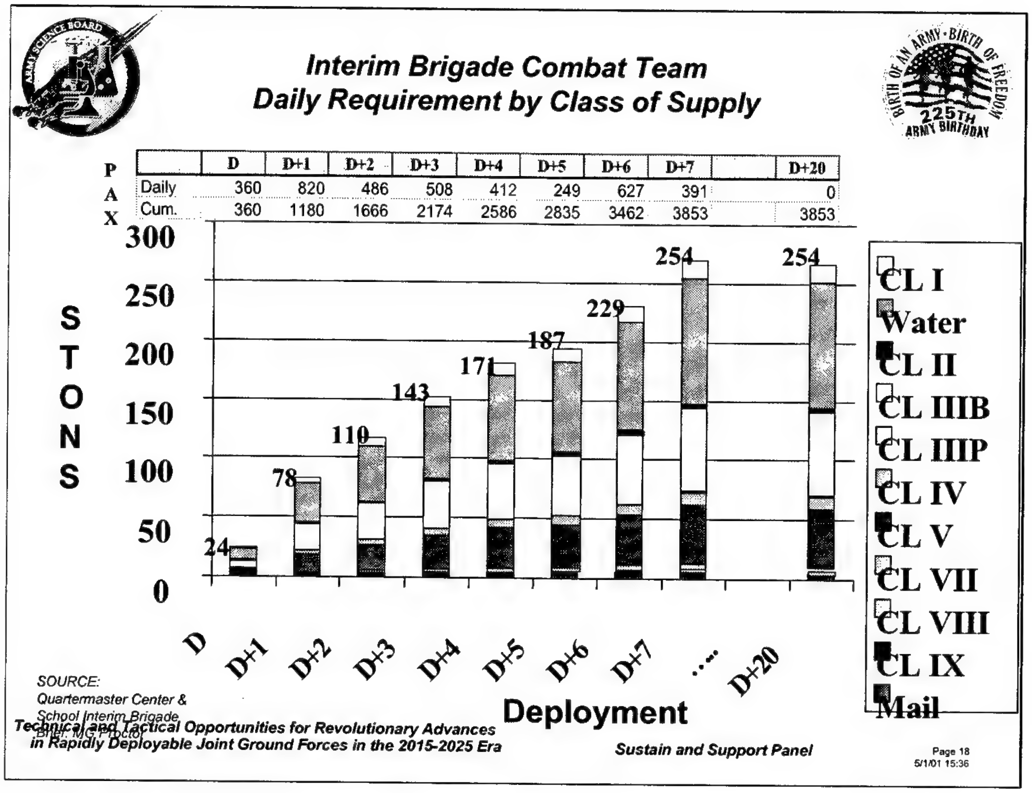
Water Generation and Purification

- Water constitutes 20-40% of the STONs of daily supply for the BDE
- Currently 31 countries are short of fresh water -- growing to 48 countries by 2025
- Lighter, more deployable water support can reduce sustainment demands and the logistics footprint; it can also be a strategic and tactical advantage
- DARPA and TACOM/TARDEC is demonstrating revolutionary technologies for water generation and purification
- Water generation by a unit on the move attacks the fundamental problem of water logistics-- DISTRIBUTION

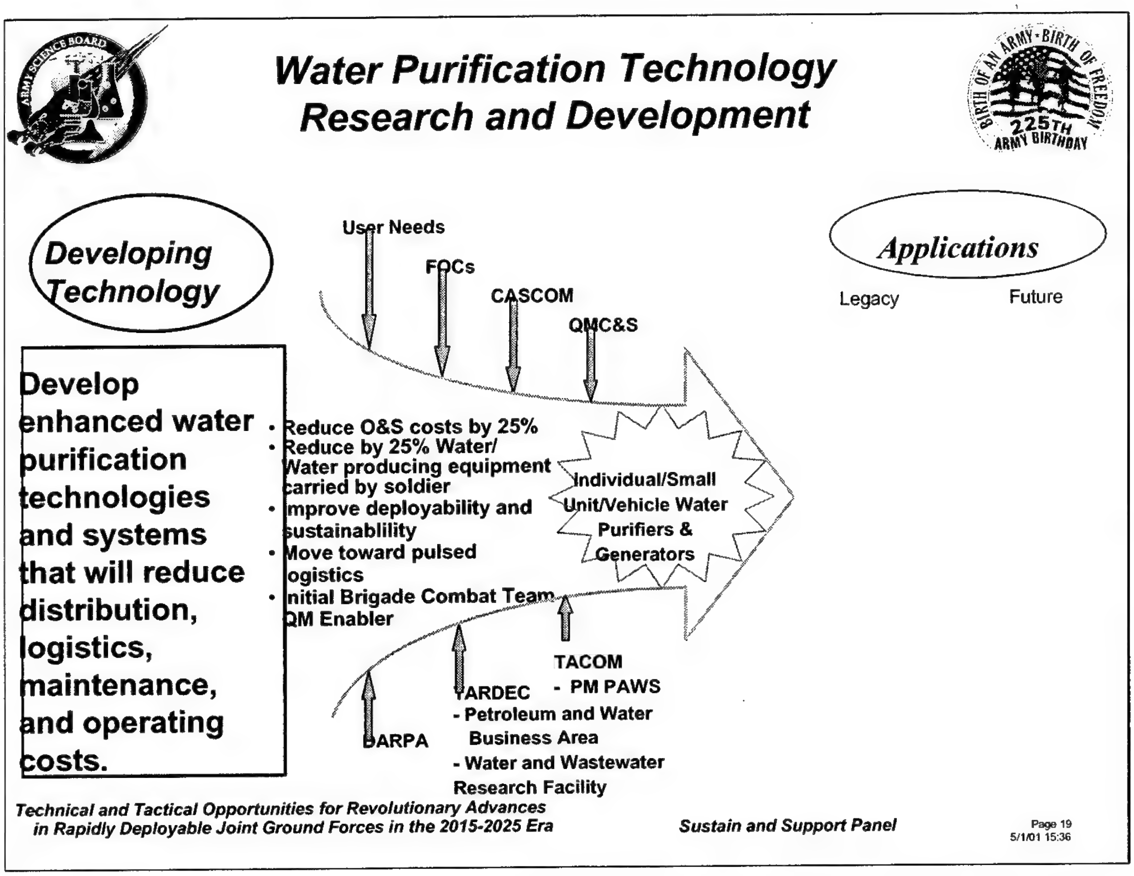
Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era *Sustain and Support Panel* Page 17 5/1/01 15:36

Water is a major factor in resupply on the battlefield. With today's force, it is about 20% of the tonnage of supplies. But with fuel efficiencies and other measures to conserve materiel, water could be in excess of 40% of total tonnage in the future.

DARPA and TACOM are pursuing technologies that can generate pure water on the battlefield, while units are operating. This has the potential not only to reduce resupply requirements but to give strategic and tactical advantages to our forces.

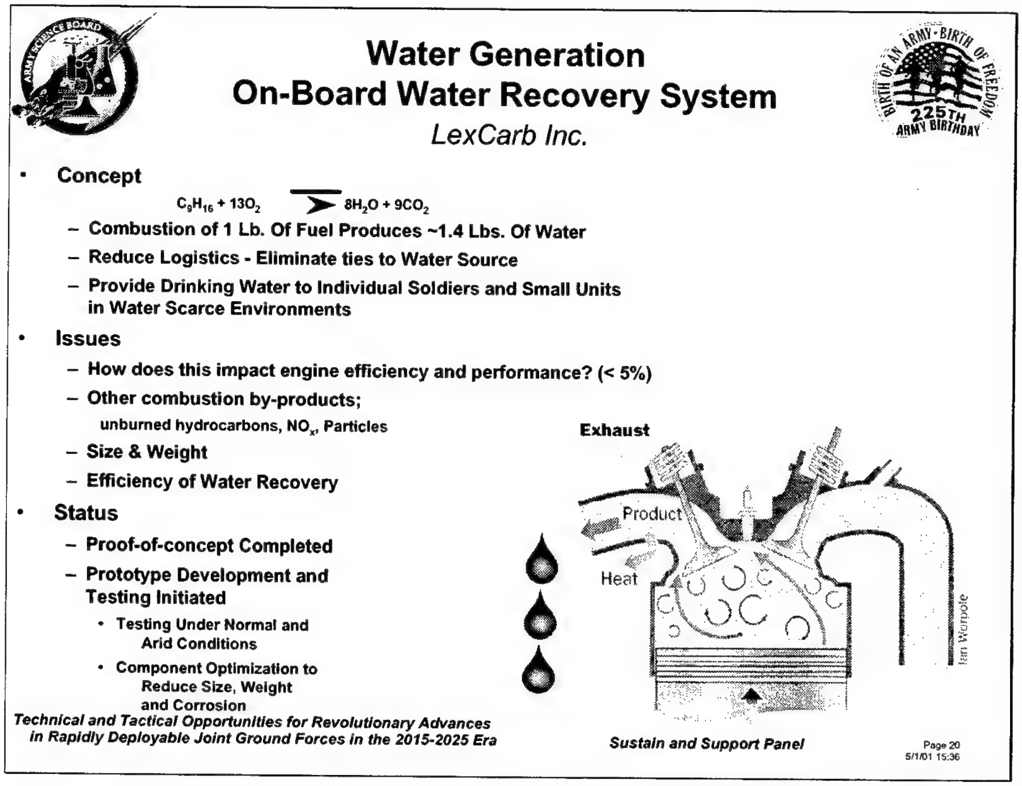


This slide shows water in dark gray and its position relative to other classes of supply.



The R&D program for water purification technology, if successful, will lead to individual small unit or vehicle-mounted water purifiers and generators. The objectives are to reduce operating and support costs, reduce the amount of man-portable equipment, and improve the deployability and sustainability of the FCS force.

The research is considering the needs of the user and is receiving inputs from both CASCOM and the Quartermaster Center and School.



One promising new technology-- the one furthest along in the R&D cycle-- generates water out of the fuel exhaust from diesel engines. The theoretical maximum is 1.4 lbs. water for each gallon of diesel fuel burned. Filters and treatment of the water would remove impurities.

There are a number of questions, including the effect on engine performance, the size and weight of the system, and the potability of the resulting water product.

A proof of concept has been completed and a prototype initiated.

On-Board Water Recovery System Technology

<u>Technology</u>

- Smaller, More Efficient, More Robust Heat Exchanger to Condense Water from Exhaust Gas
  - Minimize Pressure Drop
- Incorporate an Ambulance Air Conditioning Unit
  - Increase Recovery >1 gal water/ gal fuel
  - Reduce Air-to-Air Heat Exchanger Size
  - Allow Operation in Harsh Environments

◆ Designer Ion Exchange Resins (IERs) Remove Metals and Anions Identified During Proof-of-Concept

◆ Advanced Activated Carbon Fiber (ACF) Monolithic Filter
  - ACF Removes Unburned Hydrocarbons & Organic Combustion By-Products
  - Novel ACF can be Molded Into any Shape, Allowing Encapsulation of IERs, Installation Independent of Orientation, & Elimination of Channeling

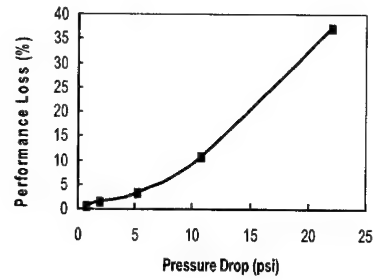
Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era   *Sustain and Support Panel*   Page 21 5/1/01 15:36

The prototype will attempt to demonstrate improvements in size and efficiency of the system.

On-Board Water Recovery System Results

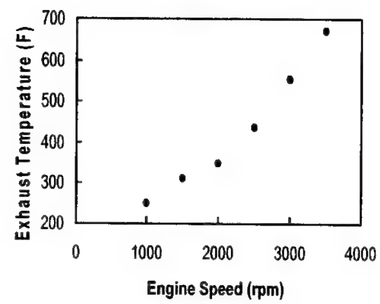
Phase I Results:

- Produced up to 90% of theoretical 1.4 kg water/ 1 kg diesel burned
- Water quality met TB Med 577, in fact better than Lexington, KY tap water
- 3 Inorganics (Al, B, Mn) below drinking limit, but improved removal investigated in phase II
- pH fluctuated 5-9 as ion exchange resin aged, investigate ion exchange resin life & new resins using Na and Cl rather than H and OH



New Results on a HMMWV:

- Pressure drop in system < 1 psi
- 1% loss in engine performance per psi
- ~ 0.7 gallons water/gallon of fuel consumed
  - improvements with better HXs
- Solids collected ~ 20 mg/liter of water collected
  - mostly soot and metal shavings
  - improved by heresite coating on HX17



Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era

Sustain and Support Panel

Page 22
5/1/01 15:36

The proof of concept results were quite interesting. The test achieved more than one lb. of water per lb. of fuel. The resulting water met the medical standard and was better than drinking water in certain communities. Some areas need improvement in removing inorganic compounds.

When tested on the HMMWV, there was only a 1% reduction in engine efficiency. The results to date show the potential for eliminating resupply of water on the battlefield.

Water Generation
On-Board Recovery System

- **Issues**
  - **Incorporating in FCS represents a tough trade-off in size and wt.-limited system**
  - **Improvements in design and efficiency (especially size) needed**
  - **Alternative concepts being explored by TARDEC and DARPA**

- **Conclusion**
  - **A very promising area with major benefits in support and sustainment**

We can foresee three issues. To take advantage of the technology in combat units, it should be incorporated into the FCS design. The design will be subject to tradeoffs along many dimensions to achieve its weight targets. Water generation is a potentially weight saving, if it results in less water being carried by the force to support the soldiers.

A number of designs improvements are needed.

Third, DARPA and TACOM are exploring other technologies with the potential to generate pure water on the battlefield.

This is a promising area with major benefits for the support and sustainment of the FCS force.

Reduced Battlefield Footprint

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era *Sustain and Support Panel* Page 24 5/1/01 15:36

One of the stated goals of the study is "to reduce the logistics burden" of the force. This isn't easy. We must achieve the same or better level of logistics support as the current force. Moreover, the FCS concept of operations will require continuous operations for days and weeks and support must occur "on the run."

Reduced Battlefield Footprint

Why?

- **Faster deployment, lower sustainment, greater tactical mobility and agility, fewer casualties**

How?

- **Echeloning of support to theater and ISB**
- **Tactical tailoring of dynamic forward logistics elements**
- **Move materiel distribution to ISB-- 'reach back'**
- **Maintenance rules: 'replace it, don't fix it'**
- **Medicine-- stabilize and evacuate**
- **Provide other services remotely as far as practical**
  - **Signal: all C-E should be networked**
  - **Intelligence, including UAVs**

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era *Sustain and Support Panel* Page 25 5/1/01 15:36

The benefits of reduced battlefield footprint are clear.

To achieve these results, we have a variety of actions that can be examined.

First, we can create support concepts for supply and maintenance where more work occurs at higher echelons outside the battlefield and above theater.

Second, we can tailor our tactical support to meet the needs of a given force and mission.

Third, we can institute 'reach back' on materiel supply to areas outside the theater.

Fourth, we can develop maintenance concepts of replacement rather than repair, whereby we replace components and assemblies by operators or tactical support and avoid repair of components in theater.

Fifth, for battlefield medicine, we can move even further towards a policy of evacuation, following stabilization of the patient-soldier on the battlefield.

Sixth, we can move as much as possible of our signal, intelligence, and administration assets outside the battlefield, and even the theater.

Challenges in Reduced Footprint

- Major problem-- a 'taut' system with many points of failure
  - Must build redundancy without building mass
  - Primarily for rapid deployment and early operations
- Goal of unit self-sufficiency for 7 days not a sure thing
  - Even with resupply of fuel, ammo, rations
- Commanders will require absolute assurance of the operation of the supply chain and information systems for flow of assets
- Supporting agile and mobile combat force may require the support forces to be as agile and mobile as the combat units
- Logistics C2 and systems must achieve high capability and efficiency to coordinate many echelons in crisis actions
  - Difficult in a very different peacetime environment

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era — *Sustain and Support Panel* — Page 26 5/1/01 15:36

The leaner support posture for FCS has risks and challenges. A fine-tuning of the support structure may create many areas with single points of failure; this is intolerable on the battlefield, and we must look for ways to build redundancy without building mass.

The FCS goal of seven days of operation without resupply is a demanding goal. In the extreme, it could demand that enough fuel, rations, water, and ammo be carried on board to sustain the mission for the entire week. Such tradeoffs in system design may compromise the lethality and effectiveness of the system. Even if we institute rapid resupply for the basic consumables, the required reliability to operate a force for a week or longer without maintenance is well beyond our experience with complex systems.

We must substitute the supply chain for the 'iron mountain.' Commanders will demand absolute assurance of the operation of the supply chain before accepting the substitution. A proven in-transit visibility system and the positive experiences of successful operations of the supply chain are just beginning steps in a radical change of Army culture.

Fourth, the tactical support for the FCS must be as agile and mobile as the combat squadrons and troops in the FCS. Our CS/CSS forces have not traditionally been developed with this capability. Improved agility and mobility requires culture and training.

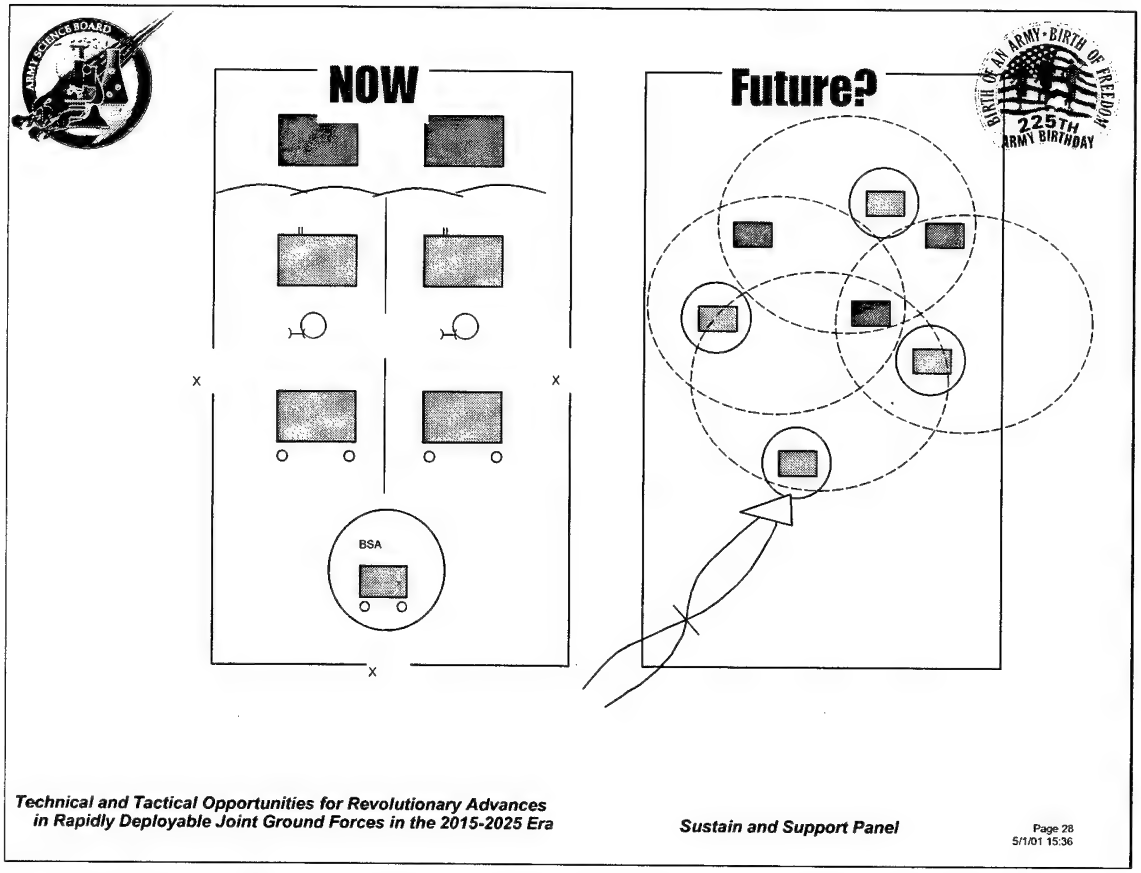
Fifth, the logistics C2 systems must achieve a very high level of capability to coordinate activities on a global basis. This will require a high degree of training and regular exercises and a commitment of time and energy by a community with important peacetime activities in materiel management, maintenance, and distribution.

Support Strategies

- **Execution-focused support**
  - **Continuous in-stride adjustments**
- **Seamless battlefield distribution**
- **Logistics support operational concept**
  - **"Ask and you shall receive!"**
- **A global approach: reduced theater footprint**
- **Innovative new approaches to medical care**

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era   *Sustain and Support Panel*   Page 27 5/1/01 15:36

We will look at these support strategies as a way of achieving the capabilities desired and reducing the risks inherent in the FCS.

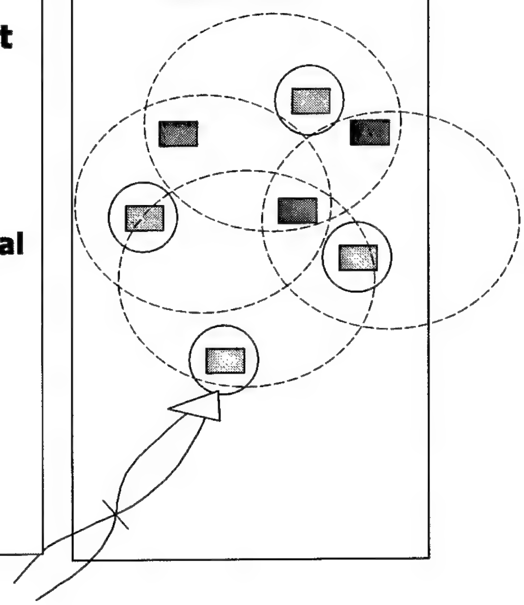


We begin with a recognition that the battlefield will change radically from that long recognized in traditional ground warfare-- not to mention the modeling and simulation systems of the past four decades. The FCS force will be able to operate freely with a high degree of mobility and agility. Consequently, the concept of 'rear areas' and 'supply lines' will reflect a non-linearity not present in the traditional view. Our support concept for the FCS must reflect this reality.

Revolution in Tactical Support

- Pulse of operations from 3 to 14 days
- Maneuver units designed for self-sufficiency
- 'Pit-stop' like resupply for critical combat needs
- Synchronization of battle and logistics rhythm
  - -- Rapid, fluid adjustments
- Support forces must be able to operate at distances of 500 to 1,000 kilometers

FUTURE



Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era

Sustain and Support Panel

Page 29
5/1/01 15:36

Our new approach to tactical support must support a pulse of operations ranging from 3 to 14 days. To do this, the FCS must have a high degree of self-sufficiency designed into the force and the system. The support units must be capable of resupply on the run, including an almost pit-stop like capability. The logistics and battle rhythms must be synchronized, not only during the planned intervals of operations but also the rapid adjustments made during the real-life battle. Moreover, support must be provided at extreme distances during this highly mobile warfare. Tactical support units must embody these capabilities.

Ultra-Reliability

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era

Sustain and Support Panel

Page 30
5/1/01 15:36

Ultra-reliability provides a significant opportunity to reduce the level of activity and the costs of maintenance and support on the battlefield and during intervening peacetime. It reduces workload, personnel and the number of units required in the Objective Force structure. This presentation will show that ultra-reliability has the effect of reducing the logistics footprint by reducing or eliminating the spares inventory and maintenance-repair personnel. Although it is difficult to quantify, there will be significant reduction of floats (spare units at Division level in case of equipment failure).

Ultra-reliability Benefits

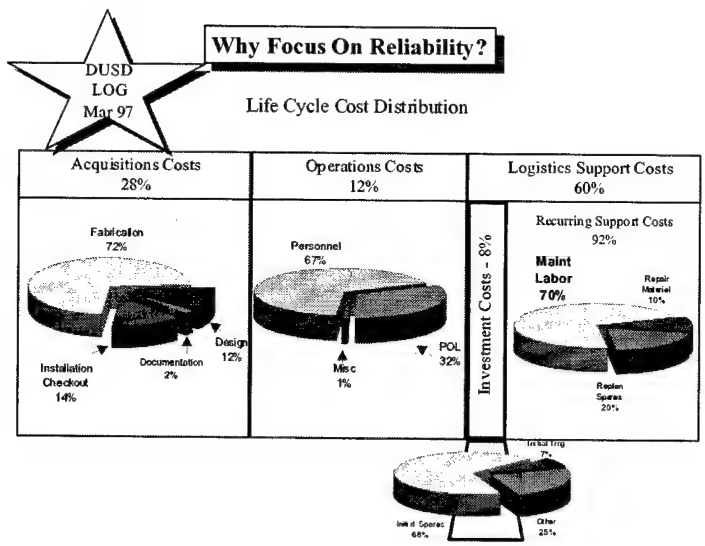
- Results in significant reduced logistics burden.
  - Removes repair personnel from AO
  - Reduces floats (extra vehicles and materiel to anticipate system failure)
- Technology supports significantly greater systems reliability.
  - Self evaluating systems
  - Self correcting systems (e.g., JTR Rotor)
- Battlefield maintenance simplified.
  - Programmable sensors linked to supply chain
  - Advanced Repair and Maintenance Vehicle (robotics)
  - Modular repair v. parts repair

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era *Sustain and Support Panel* Page 31 5/1/01 15:36

Ultra-reliability is a key to enabling the goal of logistics reductions required by the Objective Force. The AO logistics reduction from ultra-reliability is so readily apparent that it is easy to get leadership to endorse the concept. Even though the savings are obvious, with several actual cases documented, much of the benefit from ultra-reliability remains to be calculated to go beyond anecdotes. As this presentation will show, getting to ultra-reliability as a system component will take more concrete measures and quantifiable results.

The next few slides will address the challenges to attaining ultra-reliability, including cultural and structural challenges in addition to the S&T challenges. Once we outline the challenges, we highlight some promising developments that we believe should be encouraged. We also make some recommendations for actions, such as future analysis to determine the full extent of the reduction in the logistics burden due to ultra-reliability.

Ultra-reliability Benefits



Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era *Sustain and Support Panel* Page 32 5/1/01 15:36

The graphic shows a "big picture" view of the benefit from ultra-reliability. There are several ways to interpret this information. One interpretation says that ultra-reliability reduces service/support personnel in the Objective Force AO by 83% *. Although some may argue with this number since it can be viewed as a "peace-time" metric and not necessarily applicable. None the less, it shows a substantial cost and personnel savings from ultra-reliability.

The number seems conservative to this analyst, especially since ultra-reliability means fewer "spare units" in the AO. Eliminating the current practice of spare units (called floats) means ultra-reliability will have the a multiplier effect on the reduction of operating and maintenance personnel.

(The rationale is based on the total life cycle cost as follows:
operating cost = 8% labor + 4% POL&Misc = 12% of total
support cost = 5% init spares + 38 % Labor + 17% other = 60% of total
which ⇒ 8% + 38% = total system costs due to labor = 46%
assume no support personnel ⇒ 38%/46% = 82.6% reduction)

Ultra-reliability Metrics

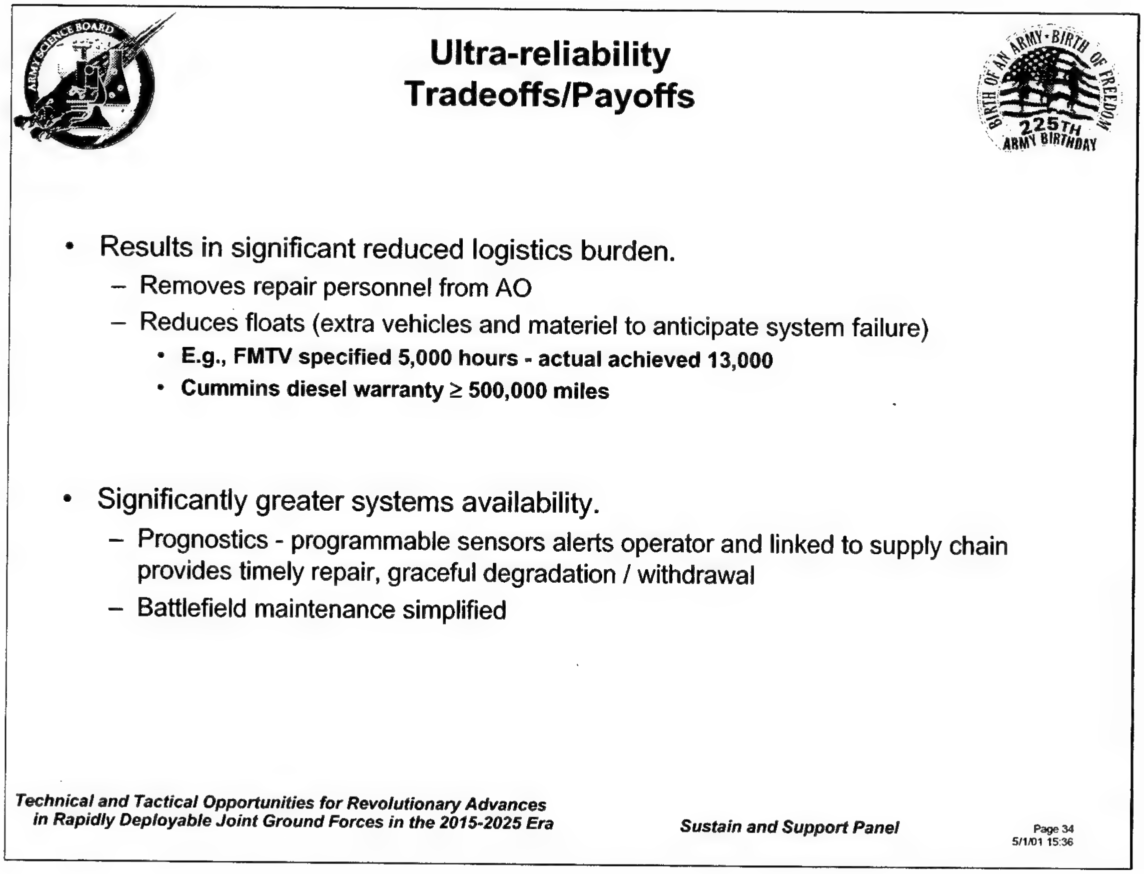
- Ultra-reliability: The probability greater than 0.99 that an item will function as intended without failure for 7 days*.

- Reliability Metrics:
  - MTBF or average interval between failures:
    - Mean time between essential function failures
    - Mean time between system aborts

- Ultra-reliability Metrics:
  - Maintenance free operating period
  - Failure free operating period

* Reference Mission Needs Statement (MNS)

To give meaning to the concept of Ultra-reliability, we must go beyond traditional measures such as mean time between failure (MTBF). The value of introducing ultra-reliability metrics vs. reliability metrics is to make the point that ultra-reliability is absolute. Ultra-reliability metrics are binary, i.e., a system either meets the ultra-reliability standard for a specific mission duration or not, where as reliability metrics only provide non-qualitative measures of system reliability, without reference to mission objectives. In order to change the Army mind-set, it is useful to introduce ultra-reliability metrics that are quantitative and represent mission systems goals.



Self explanatory

Strategies for Ultra-reliability

- Tradeoffs / Payoffs - Models and analysis to show the costs and benefits of improved reliability of systems and weapons
- Prognostics and diagnostics: Technologies to forecast failure and remediate
- Inherent reliability: Science & Engineering principles of failure and reliability become part of system design and development
- Procurement and acquisition: Specify reliability along with other procurement criteria

To achieve our goals of ultra-reliability, there are a series of strategies to be pursued.

First, we need to understand that the benefits of ultra-reliability exceed the costs associated with achieving that level of performance. Models and simulation can help show the trade-off involving reliability.

Second, prognostics and diagnostics, which involve the use of imbedded sensors to predict and analyze failure, can ensure system performance and reliability by enabling maintenance actions to be taken prior to potential failures.

Third, the pursuit of system reliability must apply scientific and engineering principles.

Fourth, we do not yet know what reliability can be achieve unless we specify it as a key performance parameter (KPP) in systems procurement.

Commercial Example of Ultra-reliability payoff

- Boeing Commercial Air Group - 737 commercial fleet.
  - Redesign of the entire aircraft focused on the reduction of maintenance man-hours.
  - Boeing Next Generation 737 able to realize a 15% reduction in maintenance cost
  - Boeing attributes this success to the use of:
    - Integrated Product Teams
    - Digital design
    - Component-level Cost Modeling
    - Airline "*Working Together*" Groups
- Cummins Diesel N14 Plus
  - 525,000-Mile (844,905 km) CENTINEL™ System: Advanced engine oil management system
    - Oil filter change every 100,000 miles for over-the-road / or, every 1,000 hours in heavy construction
    - Oil change every 525,000 miles for over-the-road/ or, every 4,000 hours in heavy construction
  - 2 years unlimited miles warranty / 500,000 mile warranty on major components
  - Life expectancy 700,000 miles before rebuild (over-the-road)

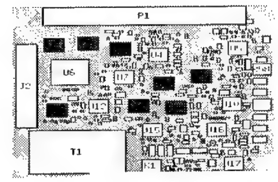
It is clear that the private sector understands the benefits of ultra-reliability.

In the Boeing example, the entire system costs were reduced by 15% through an upgrade program. Since maintenance represents about 60% of fleet life-cycle costs, it is easy to see the bottom line impact of a 15% reduction in life-cycle costs in a commercial operation. In addition, the increased reliability allows for decreased liability insurance costs.

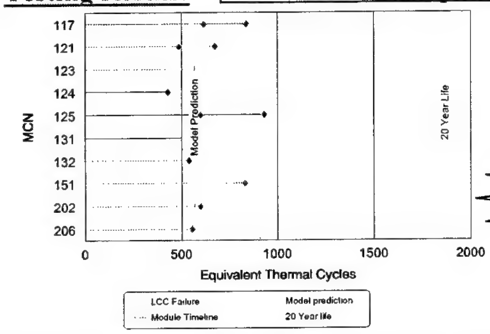
In the Cummins example, market demand for greater system availability yields engine life exceeding 700,000 miles and service intervals exceeding 100,000 miles.

Military Example of Ultra-reliability Payoff
ARC-210 Radio

- Analysis Results:
  - 20 pin Leadless Chip Carrier was weak in design
  - Estimated life under operating conditions - 6.5 years
  - Assess reliability of the module in a military environment
  - Improve reliability of the module



Testing Resuts: **Failures occurred as predicted**



- **5,000 units fielded - 20 years field life**

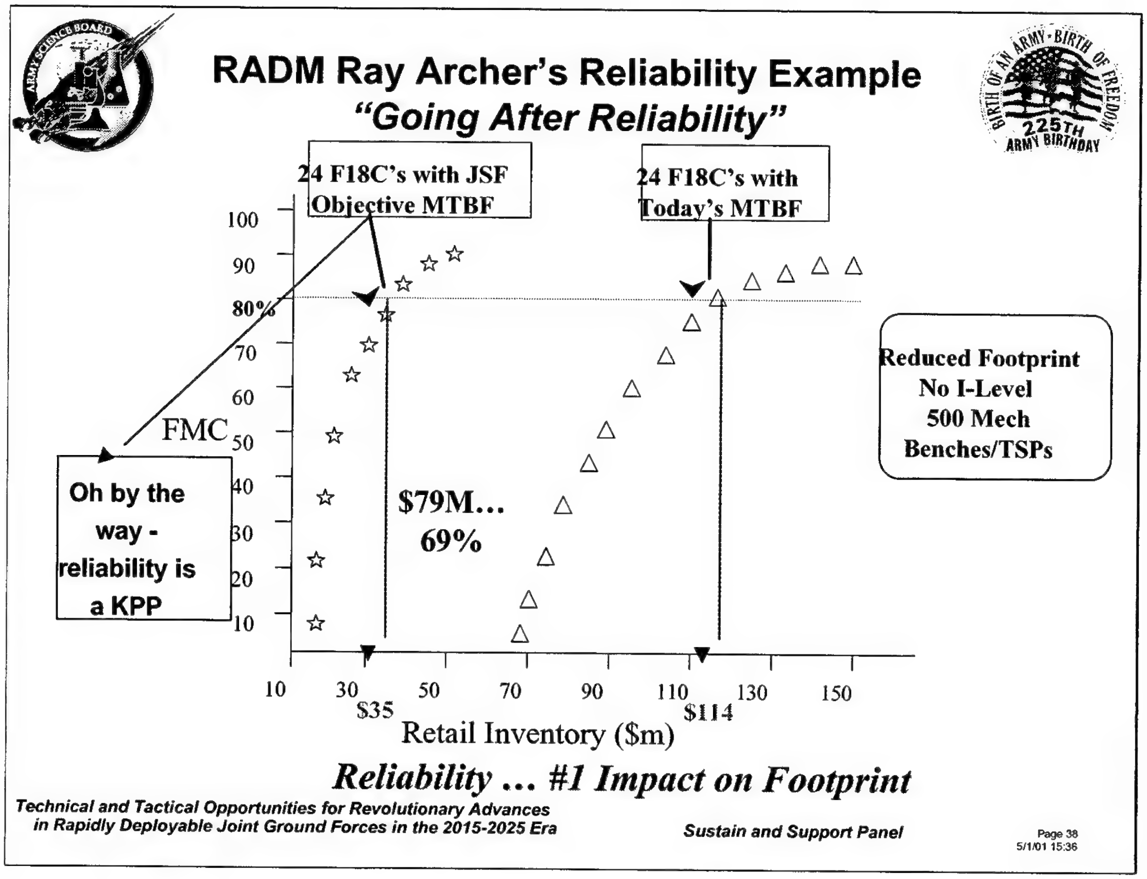
Operating & Support Cost Avoidance
$27,000,000

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era

Sustain and Support Panel

Page 37
5/1/01 15:36

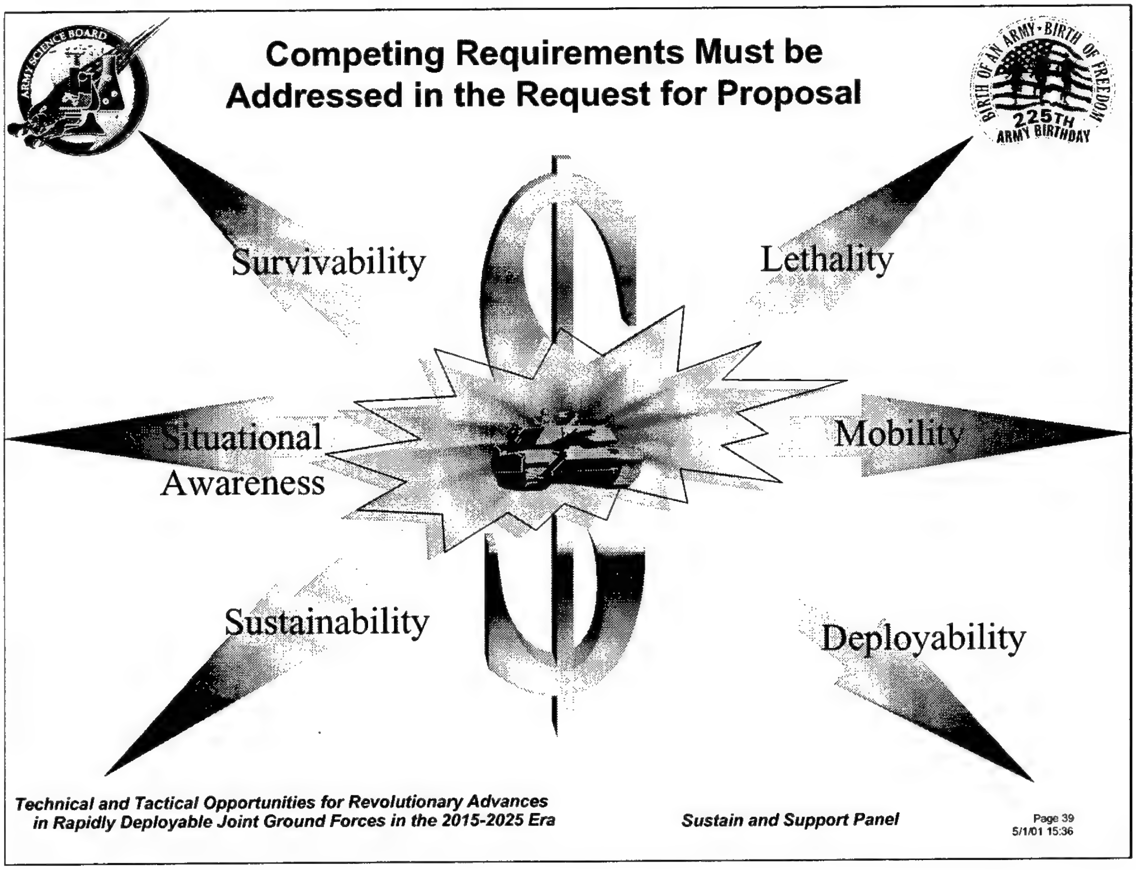
The DoD and Army have success stories to demonstrate the potential from ultra-reliability. In this case the use of Physics of Failure (PoF) analysis in an AMSAA project resulted in a 3 fold increase in reliability and a $27 Million cost avoidance.



In the Joint Strike Fighter program, RADM Archer expects to reduce spares significantly through an emphasis in reliability (making it a KPP).

Based on the analysis presented in this slide, ultra-reliability will reduce maintenance actions by 70%. This represents substantial reduction in spares inventory and substantial reduction in maintenance personnel footprint.

This is the kind of modeling that needs to be developed during the procurement specification period. This slide is an excellent example of real life studies to predict the value of ultra-reliability in terms of projected logistics reduction.



This is the first of two slides addressing the need to put ultra-reliability into systems procurement. These two slides express the idea that the challenge in achieving ultra-reliability has a technology component and a culture/business rules component.

This slide shows that ultra-reliability competes for dollars during the design and development stage of new systems. During system specification the cost associated with ultra-reliability will be balanced, or traded-off, against other systems requirements. This will be true even though the "down-stream" ownership and logistics costs will offset the initial investment (unlike the other requirements). It should be noted, however, that ultra-reliability is the only systems design criteria that has an impact on lowering the life-cycle costs for new systems. Not only will ultra-reliability enable the sustainability of the Objective Force, but *Ultra-reliability pays for itself in life-cycle cost savings (ROI).*

We recommend the Army institute a learn-by-doing program for ultrareliability. A straightforward way to do this would be to use an existing program now as a vehicle and not wait for a 2006 EMD.

Objective Force Ultra-reliability Requirements Means New Acquisition Paradigms

- Change in system acquisition culture
- Reliability as "Key Procurement Parameter" implies:
  - Reliability must be built into system designs
  - Commonality across systems reduces spares inventory
  - Measurable reliability statistics part of design criteria
- New tools for PM to measure and evaluate KPP compliance during development
  - Physics of Failure Analysis
  - Update & support <u>Failure Mode, Effects, and Criticality Analysis</u> (FMECA) - MIL-STD-1629A

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era *Sustain and Support Panel* Page 40 5/1/01 15:36

The emphasis on reliability may require a change in system acquisition culture that gives projected gains in system availability and cost of ownership the same priority as system development costs.

This is the second of two slides addressing the need to put ultra-reliability into systems procurement. These two slides express the idea that the challenge in achieving ultra-reliability has a technology component and a culture/business rules component. This is really a conclusion to the prior slide. The only way to balance the competing demands is in the systems selection criteria. This must be designed into the specification and administered by the procurement team.

To include reliability as a KPP means that system design must be engineered to achieve the reliability goal specified and that the design criteria must include reliability metrics. It is unwise to rely totally on the claims of vendors during the system development stage, so after adding the specification into the design criteria, Program Managers will need tools to evaluate compliance of vendors with the specifications.

Promising Developments

- Physics of Failure (PoF) research and development resulting in tools for measuring and evaluating reliability
  - determines reliability impact of technologies under different conditions
  - Measures for design robustness
  - Evaluate the impact of modeling assumptions on reliability (e.g., by determining whether damage-accumulation failure mechanisms will impact reliability)
  - Developed by a government-industry consortium with confirmed results
- RFP for FMTV
  - Specified ultra-reliability @ 5,000 hours, actually achieved 13,000 hours.
  - New RFP has increased specification to 10,000
    (but maybe not aggressive enough?)

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era *Sustain and Support Panel* Page 41 5/1/01 15:36

Physics of Failure has been growing in support within CASCOM and AMSAA. The modeling of failure and the tracking of failure mechanisms and systems failure data is a very promising area for the Army.

The two major benefits proposed to the Army from the efforts on Physics of Failure are:

1. The ability to specify, in advance, and evaluate the design criteria for ultra-reliability. Contractors will be able to use PoF models in responses to RFPs that will demonstrate their system designs and the systems' ability to yield an ultra-reliable result.

2. The ability to investigate and resolve reliability failures during systems development. Since simulation of design functions will never replace live field testing, PoF will have value in the design phase, and in the test phase to ensure ultra-reliability.

Recommendations

- Develop Objective Force reliability acquisition metrics
  - E.g.a, NASA Software Engr. Reliability metrics:
    - **Low Reliability** P(f) during a 1 hour mission of greater than 0.001
    - **Moderate Reliability** P(f) during a 1 hour mission between 0.001 and 0.0000001
    - **Ultra Reliability** P(f) during 1 hour mission of less than 0.0000001
- Need similar metrics for Objective Force reliability
- Use Physics of Failure (PoF) modeling as acceptance criteria for future systems R&D

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era *Sustain and Support Panel* Page 42 5/1/01 15:36

The Army needs to define ultra-reliability. It is recommended that the Army work in concert with industry to arrive at ultra-reliability definitions for future systems. In order to better specify, and then evaluate, ultra-reliability performance, the Army should continue to invest in the Physics of Failure (PoF) consortia (e.g. the AMSAA CALCE). Physics of Failure provides a framework for models, simulations and other methods that all contractors can use to demonstrate system reliability. It is not recommended that the Army fund its own PoF R&D centers, but rather that the Army fund industry consortia and buy the PoF technology.

We further recommend, for ultra-reliability, a learn-by-doing approach using an existing program and starting now, rather than in 2006. This has been previously discussed.

Recommendations
Design & Operations

- Design and development recommendations for ultra-reliability
  - Acquisition reform to include as KPP in systems requirements
  - Expand PM use of failure mode, effects, and criticality analysis (FMECA) - MIL-STD-1629A
  - Expand funding for Physics of Failure (PoF) research consortium

- Readiness tracking system to maintain ultra-reliability
  - Maintain central system status tracking
  - Life consumption modeling for fatigue failures & Characterization of stress/load profiles
  - On-board systems status data (drive-through diagnostic shelters will be used before combat engagements)

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era *Sustain and Support Panel* Page 43 5/1/01 15:36

- This is the second of two slides to make the point that there are two sides to the ultra-reliability coin:

  •First, how to achieve ultra-reliability

  •Second, how to keep it there once you achieve it.

- *Readiness Tracking System:* Once a new system is out of the box and into use the question becomes how to keep track of which systems are still ultra-reliable. The present equipment inventory database system, including the maintenance record keeping system, needs extensive improvement to meet the objective force MNS.

Ultra-reliability is a consumable. Training and mission assignments will degrade systems reliability, resulting in systems that need routine maintenance, module replacement, or systems upgrades to re-qualify as ultra-reliable. To achieve the MNS force deployment in 96 hours without sustainment for 7 to 10 days, the Army will need to "cherry-pick" from among the FCS that meet the ultra-reliability standard.

Recommendations
Prognostics & Diagnostics

- Prognostics
  - Invest advanced programmable sensor technology
  - Prognostics linked to supply chain
  - Prognostics alerts to operator to facilitate graceful degradation/ withdrawal
- Maintaining systems - Diagnostics
  - Highly maintainable system designs
  - Common platforms
  - Uniform diagnostic data bus
  - Modular v. component spares & spare status instantly available
  - Built-in prognostics and programmable sensors to alert impending failure
  - Dual-role operator-maintainers use prognostics before actual failures

This is the second of two slides to make the point that there are two sides to the ultra-reliability coin:

•First, how to achieve ultra-reliability

•Second, how to keep it there once you achieve it.

Applying the definition provided in this brief for ultra-reliability has substantial impact on the ability to diagnose system status, predict system performance, and maintain/repair of systems. The existing Army methods must be upgraded, improved or over-hauled. For example, BMW automobiles have a system of four green lights, a yellow light and a red light that notify the driver of engine condition. The on-board omputer tracks time, engine revs, acceleration, braking, torque, etc., and turns the lights out as the system gets closer to needing service. All lights on means the system is good to go, yellow and red means service needed, while only the red means service overdue.

New sensor technology allows sensors to detect subsystem status and potential problems (metal in oil, vibration signatures, use and operation data). Sensor data provides prognosis of subsystem life and diagnosis of impending or extant system failures.

Maintaining systems to a standard of ultra-reliability will require extensive upgrades to the spare parts management systems. During our interview at AMSAA we were told that the Army doesn't track spares in the field. This creates a situation that would allow spares to be re-used without meeting full testing or reconditioning. In addition to improved parts management information system, spares could maintain their own experience. By adding a micro-chip into spare parts, the spares' history and reliability status would always be available.

Recommendation

- Make ultra-reliability a KPP for FCS
- And -- Oh, by the way:
  No Reliability/Supportability KPPs for ICBT and FCS!!!

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era

Sustain and Support Panel

Page 45
5/1/01 15:36

Currently reliability is not a KPP for the FCS. Clearly, it should be.

Telemedicine: Background

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era *Sustain and Support Panel* Page 46 5/1/01 15:36

Telemedicine has been in existence since the invention of the telephone. With the aid of telephone, medical professionals can interview a patient at distance and acquire some (if not all) of the information needed to perform whatever activities are needed, e.g., early diagnosis and prescription of medication and other treatment.

Telephonic telemedicine has been practiced by medical professionals for years, whether they were allowed for cost reimbursement by the health insurance companies or government medical programs.

Telemedicine was recognized and well publicized when NASA began telemetering health information across great distances between spacecraft and the Earth to gain in-depth understanding of health conditions of animals and human being in outer space under weightless conditions.

Lately, telemedicine has gained a lot more publicity and wider employment when video teleconferencing (VTC) and voice over Internet Protocol (IP) become more readily available and at more affordable cost.

As component technologies and system integration technologies become more available, mature and reliable; as legislations more broadly allow the coverage of telemedicine expenses by Medicare, Medicaid and various health insurance policies; and as the medical profession is legally allowed to practice medicine across jurisdictional boundaries, telemedicine will become a general practice instead of sporadic instances of applications in the near future.

Global Telemedicine: Army's Involvement and Its R&D Budget

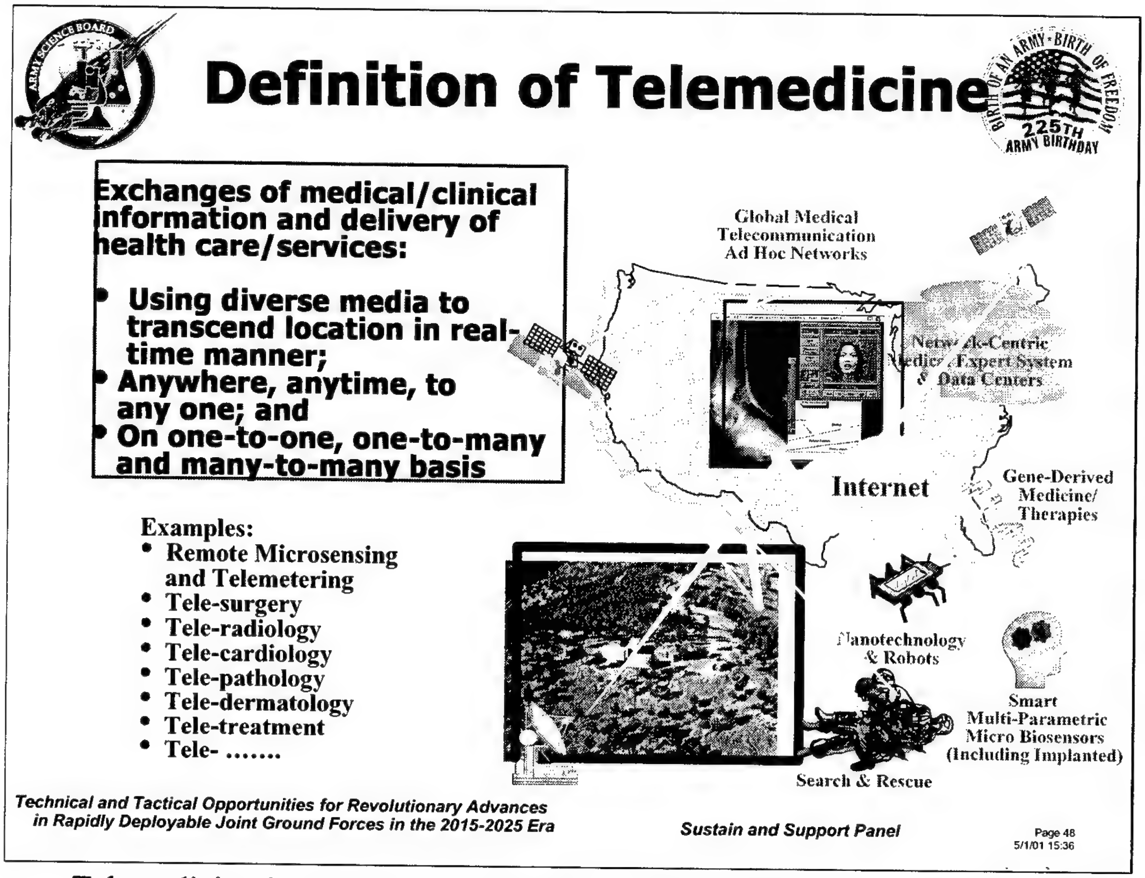
Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era | *Sustain and Support Panel* | Page 47 5/1/01 15:36

Some time in 1992, U.S. Army began promoting and implementing various telemedicine technologies. For the above reason, the U.S. Army Medical Research and Materiel Command (USAMRMC) purposefully established Telemedicine & Advanced Technology Research Center (TATRC) to conduct research and development for telemedicine, deploy telemedicine technology and promote telemedicine practices. USAMRMC should also be commended for being (1) instrumental in collaborating with industry and academia to establish telemedicine and (2) a major sponsor of American Telemedicine Association (ATA) and its annual and various activities in the last few years.

Between 1995 and 1997, Army has rapidly and successfully deployed telemedicine worldwide and projected medical care/services to far-forward, difficult-to-serve areas, including: Bosnia (Macedonia and Croatia), Cuba, Egypt, etc. These incidences of telemedicine applications are very encouraging but are still considered sporadic non-routine events with limited scope.

USAMRMC has several on-going programs in the area of telemedicine, primarily through TATRC. Most of them are under \$1 million per year—not enough to show real progress.

Some of the vision and scope of the above concepts and R&D efforts are very plausible for the next decade but their budgets are dwarfed when compared to the size and scope of the mission statements.



Telemedicine is defined as "Exchange of medical/clinical information and delivery of health care/services using diverse media to transcend location in a real-time manner anywhere, any time to anyone on a one-to-one, one-to-many and many-to-many basis."

Telemedicine includes:

• Remote microsensing (or monitoring) and telemetering of sensor data, either in real time or in a store-and-forward mode via telephone wires, cables, micro-wave, optical fiber, and radio frequencies (terrestrial & satellite).

• Tele-surgery, tele-radiology, tele-cardiology, tele-pathology, tele-dermatology, tele-psychiatry, tele-psychology, other tele-treatments (e.g., tele-administering of medicine to a patient)

By 2015 to 2025, the Army can achieve a very advanced telemedicine system with at least the following systems and capabilities:

a. Global, highly secured and scalable ultra high broad-band communication networks (or, better yet, ad hoc networks available any where and any time to our forces) including network-centric unmanned ground vehicles and unmanned air vehicles (UGVs and UAVs) and manned aerial/terrestrial communication gears as part of the telemedicine concept/system, integrating the battlefield, theaters, ISBs and home land into one seamless medical info-sphere.

b. Intelligent network-centric medical expert systems and data centers. An ensemble of comprehensive and intelligent medical information and expert systems will (1) be developed and maintained in distributed fashion in several data centers; and (2) work cohesively and seamlessly to provide tele-diagnosis, tele-consulting, brokerage services for health care/medical services, and tele-treatment services.

c. Gene-derived medicine and therapies for treatment as well as tele-treatment (e.g., gene-based stabilization, rapid healing, rapid recovery, etc.).

d. Ultra-low energy, smart multi-parametric micro biosensors (including implanted ones). A dynamic array of highly secured, smart, 2-way wireless, multi-parametric and network-enabled micro sensors will continually monitor the health conditions of our warfighters and the environment in the battle-field, theaters, and ISBs.

e. Nanotechnology robots. A dynamic array of nano-devices, nano-machines and nano-robots, as a result of convergence of genetic engineering, information technologies and nanotechnologies is envisioned to (1) help monitor health conditions of our warfighters and the environment; (2) facilitate search and rescue missions; and (3) provide tele-diagnosis and tele-treatments.

f. Real-time control and tracking of medical supplies worldwide via network-enabled radio frequency identification (RFID) chips or other micro-sensor technologies.

Benefits of Global Telemedicine in the 2015-2025 Era

- **Reduction in Battlefield Footprints and Logistic Support Needed**
- **Real-Time Bio-Monitoring of Soldier's Health and the Environment (Biosensors can be one way for IFF)**
- **Real-Time Positioning of Soldiers to Facilitate Search and Just-in-Time Rescue Mission**
- **Overall Improvement in Situational Awareness in Health Sustainability of Forces in the Battlefield and Theater**
- **Real-Time Control and Tracking of Medical Inventory in the Battlefield, Theaters, ISBs and Home Land**
- **Just in Time (JIT) Delivery of Medical Care/Services Anywhere**
- **Global Availability of Special Medical Consultation**
- **Improvement of Quality of Life of Soldiers During Peace Time due to Ready Access to Health Services**

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era *Sustain and Support Panel* Page 50 5/1/01 15:36

Many significant benefits can be easily derived from global telemedicine for the military (especially the Army) from now on and, especially, in the 2015-2025 era. These benefits include:

• Reduction in battlefield footprints and logistic support needed. For examples, availability of synthetic blood with longer shelf-life and rapid healing gene-drugs will reduce battlefield supplies and logistic support for storage of natural human blood, antibiotics, etc.

• Real-time bio-monitoring of soldier's health and the environment. Real-time situational awareness of health conditions of the forces will facilitate timely and intelligent decision of how to best organize, maneuver and engage our forces in the battlefield, theaters and ISBs.

• Real-time global positioning of soldiers to facilitate search and just-in-time rescue mission.

• Overall improvement in situational awareness in health and sustainability of forces in the battlefield and theater.

• Real-time control and tracking of medical inventory in the battlefield, theaters, ISBs and homeland by tagging medical supplies with radio frequency identification (RFID) chips or other micro-sensor technologies with smart wireless connectivity to the Army's global supply chain management systems to (1) eliminate the "Iron Mountain" syndrome in the past wars, conflicts or battles and (2) promote just-in-time delivery (with appropriate built-in safety factors) of medical care/services anywhere in the world.

• Global availability of special medical consultation. With appropriate medical expert systems and data centers strategically placed, these benefits will become even more profound than what is being offered today.

• During peacetime, all of the above telemedicine functions or features will definitely improve quality of life of soldiers, reduce medical costs, and, certainly, improve the Army's recruiting efforts.

Promising Real-Time Remote Health & Environmental Sensing Technologies in the Battlefield (the 2015-2025 Era)

- **Microelectronic technology and nanotechnology promise huge gains in future sensors that are:**
  - Smart, multi-parametric, real-time, robust (7x24), ultra low-energy (e.g., pico watt), and capable of store-and-forward
  - Highly secured and real-time global positioning
  - Computer and network-centric
  - Highly secured and wireless (both transmission and receiving)
- **Real-time access to health of soldiers through implanted micro biometric sensors to facilitate:**
  - Search and rescue, emergency health care, etc.
  - Access to medical/health information on units and forces
- **Smart micro-sensors for real-time access to ambient environmental conditions including NBC**
- **Global tracking of special and high-valued materiel**

Army should invest on R&D for Battlefield-specific technologies.

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era *Sustain and Support Panel* Page 52 5/1/01 15:36

Today's sensors for health and the environment are limited to very few parameters per sensor. In addition, they are too bulky, too heavy, too expensive, with little or no intelligence, too power hungry, not robust enough for battle-field applications and, in some cases, inaccurate, imprecise or non-representative.

The convergence of nanotechnology, information technology, and genetic engineering is rapidly taking shape and will, in the conceivable future, offer promising micro-sensing technologies. For the 2015-2025 era, it is very conceivable that intelligent, smart, multi-parametric, 2-way wireless, real-time, robust (7x24), ultra low-energy (e.g., pico-watt), network-enabled, and long-life miniature bio- and environmental sensors capable of real-time delivery and/or store-and-forward of audio/video/graphic/text information will be commercially and militarily available. For example, if each detector on a biochip is to monitor one single parameter, a 500-detector bio-chip will be capable of simultaneously monitoring 500 parameters, which may include blood sugar level, blood oxygen level, concentrations of designated chemical species in sweat or saliva, blood pressure, heart beat rate, breathing rate, concentrations of selected NBC agents in the air/water/soil, etc. In fact, these sensors can be widely spread by UAVs (or other means) and deployed in the battlefield/theaters to collect critically needed information.

These microsensors would have built-in global positioning system (GPS) capabilities and non-volatile memories to store soldier's biometric information (highly encrypted) for identification purpose and as security measure.

The above-mentioned microsensors will also have built-in intelligence with on-board expert computing power to reduce/synthesize/assemble information that is eventually to be up-loaded to the ad hoc computing networks.

We could also give these microsensors the capability of being passively interrogated by friendly forces for various reasons; and the ability to go into a sleep mode or destroy themselves under certain events or when subject to enemy's interrogations or probe.

A different ensemble of network-enabled micro-sensors would also be available to identify and help monitoring/tracking medical inventory as part of the supply chain management system for medical supplies.

The private sector will certainly continue to make progress and advancement on these micro-sensing technologies, when there is potential for a great return on investment (ROI). However, there are certain technological areas, where the return on investment will be too low to attract any significant private investment, but are of genuine interest to the U.S. Army from military standpoint and/or national security reasons. Army should invest in R&D for battlefield-specific technologies.

Promising Tele-Treatment Technologies on the Battlefield (the 2015-2025 Era)

- **Rapid convergence of genomics, information technology, and nanotechnology will offer revolutionary improvements in:**
  - Performance in high-stress, high-endurance situations
  - Blood-loss prevention
  - Synthetic and gene-derived blood supplies with much longer shelf life (thus reduce medical footprint in the battlefield)
  - Genomic-based treatments for ultra-effective stabilization, rapid healing, and life sustainment (military interest)
  - Genomic-based treatments from civilian/military medical R&D
- **Battlefield treatment focuses on stabilization and then evacuation**
  - Long list of potential improvements in combat medical support
- **Internet-enabled medical expert systems and data centers for battlefield-specific medial care/service needs**

Medical breakthroughs will need Army R&D support to achieve military benefits.

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era *Sustain and Support Panel* Page 54 5/1/01 15:36

The rapid convergence of genetic engineering, information technology and nanotechnology will offer revolutionary improvements in medical treatment (and also tele-treatment) areas. Examples in this particular category of promising technologies are self-explanatory and too numerous to cite here. Some of the treatments (particularly gene-treatments) also lend themselves for distance deployment via the network-centric communication infrastructure.

Our concept of telemedicine for the Future Combat System (FCS) in the battlefield should be capable of:

(1) Monitoring soldier's health & location on real-time and demand basis;

(2) Administering certain tele-treatment procedures to stabilize injuries/ wounds;

(3) Searching and rescuing/evacuating the soldier quickly from the battlefield; and

(4) Timely application of full-scale treatment to the soldier in medical service units in the theater or the ISB equipped with full-spectrum telemedicine capabilities, e.g., tele-consultation, tele-radiology, tele-pathology, tele-cardiology, etc. The latter will be enabled by having Internet-centric medical expert systems and data centers for battlefield-specific medial care/service needs.

Many of these elements will be developed through U.S. Government (e.g., NIH, etc.) and industry R&D (e.g., pharmaceuticals, etc.). At the same time, to gain benefits for military medicine on the battlefield, the Army must sponsor or carry out its own R&D.

Recommendations for Telemedicine (the 2015-2025 Era)

A. R&D and Deployment of Key Technologies:

Funding of research and development (R&D) and eventual deployment of key technologies:

- **Network-centric and smart microelectronic bio-sensors and environmental micro-sensors**
- **Genetic treatment**
- **Nanotechnologyfor soldier/patient monitor/treatment**
- **Battlefield trauma units**
- **Internet-enabled medical expert systems and medical/health data centers for battlefield medical care/service needs**

B. Army Global Telemedicine Transformation:

- **Training of Army medical personnel for the future to create the vision for Global Telemedicine and to implement it.**
- **Transformation of Army medical research and materiel organizations to take full advantage of global trends.**
- **Development of new policies, standards, protocols, and SOPs to facilitate establishment and deployment of Army's Global Telemedicine infrastructure.**

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era *Sustain and Support Panel* Page 55 5/1/01 15:36

The recommendations contained in this slide are self-explanatory. The emphasis is to (1) conduct telemedicine R&D of military interest and benefits; and (2) transform Army medicine (including telemedicine) in terms of personnel training, organization, and policies in order to take full advantage of the revolutionary medicine concepts and technologies in the 21st century.

21st Century Battlefield Medicine

- Opportunity
  - Improve the medical care and health of the deployed force
  - Derive military benefit from revolutionary advances in technology and medicine
  - Reduce the medical footprint in the battlefield
- Discussion
  - Advances in microsensor and nanotechnology can lead to implanted micro biosensors to gain real-time access to health of soldiers in battle
  - Rapid developments in genomics will revolutionize battlefield medicine (gene-derived blood supplies, blood-loss prevention, improved performance and endurance under high stress, genomic-based treatments of trauma)
  - Medical support will emphasize stabilization on the battlefield and evacuation to facilities and hospitals in theater or above
- Recommendations
  - Increase Army medical research and focus toward battlefield benefits from nanotechnology, genomics, and other revolutionary advances in medicine
  - Train Army medical personnel for the future; transform Army medical research and materiel organizations to take advantage of global telemedicine advances
  - Focus Army medical support towards a lean stabilization and evacuation model

As a result of many deliberations and briefings by the Sustainment and Support Panel during this ASB Summer Study, it was concluded that telemedicine is only one of the many critical aspects facing the medical profession in the 21st century. The rapid convergence of genetic engineering, nanotechnology, and information technology will have profound effects on Army's transformation into its 21st century battlefield as well as peace-time medicine. All of the elements (and certainly some more) on Army global telemedicine presented above will definitely become core parts of Army medicine in the 21st century.

Consequently, it is recommended that Army (1) increase its medical research and focus toward battlefield benefits from nanotechnology, gene technology, and other revolutionary advances in medicine; (2) train and prepare its medical personnel for the future; (3) transform Army medical research and materiel organizations to take advantage of global telemedicine advances; and (4) focus its medical support towards a lean stabilization and evacuation model to further reduce its medical logistic burden.

Global Strategies for Battlefield Support

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era *Sustain and Support Panel* Page 57 5/1/01 15:36

We can best support the FCS force by a global solution to materiel distribution that takes advantage of assets and capabilities outside the battlefield and theater. A global approach helps reduce the battlefield footprint and the size of the force that must be deployed. But it must rely on information technology and data to drive the materiel distribution function.

Global View of Materiel Distribution

A global perspective is essential

- **Global materiel distribution solution**
- **Single view of logistics for the battle space**
- **Deployment and initial support**
- **Reduced battlefield footprint**
- **Echeloning of support -- Who does what where?**
- **Engagement of resources**
  - **-- Tactical, theater military, civilian, contractor, HNS**

CONUS — ISB — Theater — Brigade Support — Brigade/ FCS

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era

Sustain and Support Panel

Page 58
5/1/01 15:36

Materiel distribution activities occur in the combat units and the brigade support teams; at theater; in the vicinity of the ISB; and in the CONUS sustaining base.

To optimize this system, we must have a global materiel distribution solution that assigns responsibilities and resources to each echelon. We must achieve a single view of logistics for the battle space, supported by information systems connecting all levels.

Decisions will govern:

- The size, composition, and materiel of the deploying force;
- The ability to reduce the battlefield footprint from CS/CSS forces;
- The echeloning of support in terms of the distribution of functions and activities within and outside of theater;
- The utilization of resources such as civilian and contractor labor, host nation support capabilities; and, as necessary, military personnel in theater and within the division and brigades.

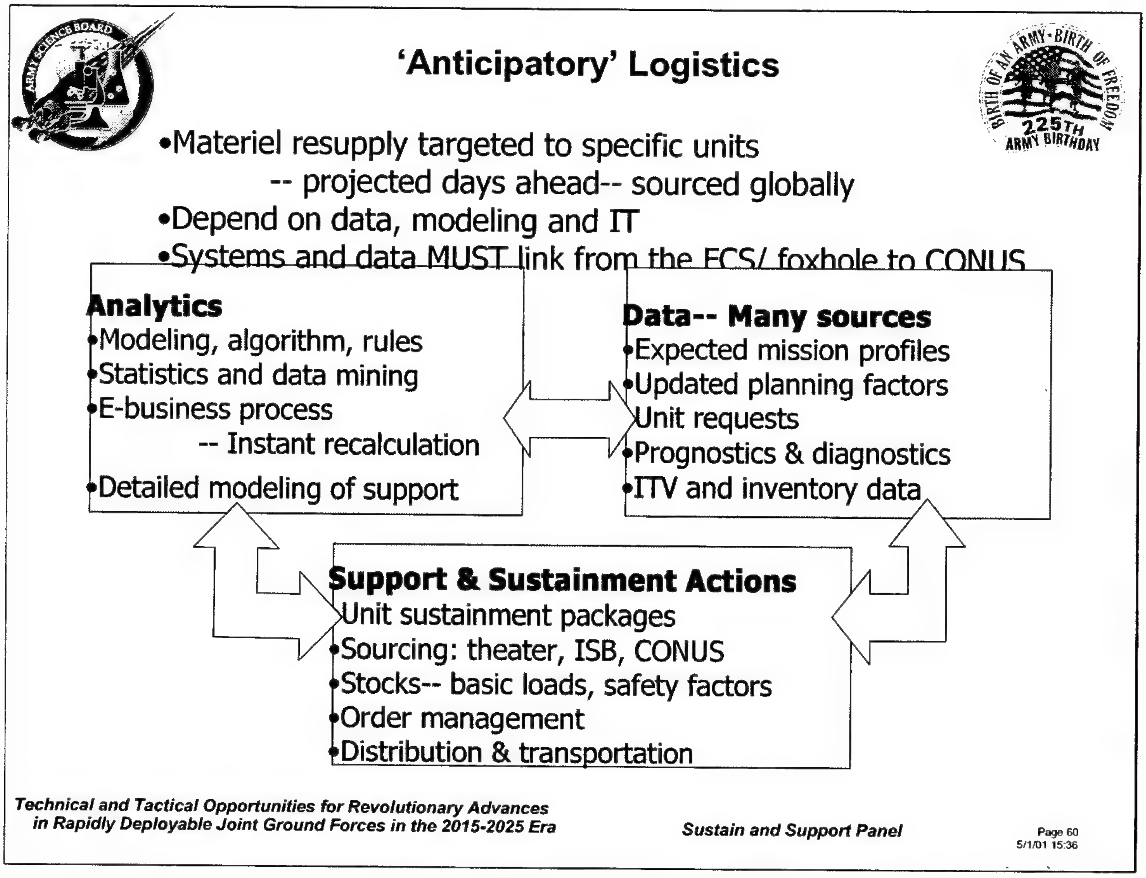
Tailored Unit Resupply From Beyond the Theater

- **Unit-configured loads assembled well outside the battle area**
- **Assembled and packaged at the notional ISB based on detailed understanding of unit requirements**
  - **Can be supplemented, if necessary, in theater**
- **Family of containers used for transport from CONUS and ISB to tactical unit**
  - **ISO containers for sealift, ground transport, and some airlift**
  - **Smaller containers (nested) for transport in theater and battle area, eventually to units**
  - **Need special equipment for the battle area**

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era *Sustain and Support Panel* Page 59 5/1/01 15:36

To optimize support subject to constraints in battle space and theater resources, we envision a materiel system that creates and ships resupply packages targeted for individual units, probably on a daily basis. These would be assembled and packaged based on a detailed understanding of unit requirements.

These loads would be transported in "nested" containers, beginning with ISO containers for inter-theater movement and smaller containers for the theater and battle space. Combat and support units would need people and equipment for transporting and unpacking the containers. These resources should be far fewer than if assembly and packing were done in theater without benefit of containers. The smaller containers could be used to return items for repair.



The ability to drive a unit-specific materiel distribution system depends on the ability to predict demand for each unit. This is the essence of anticipatory logistics.

We expect demand data from many different sources, updated planning factors, expected mission profiles over the next several days, specific patterns of demand by the unit, its own requests, and data from prognostics and diagnostics sensors in the FCS. Supply would measure the stocks on hand and the materiel in the visible pipeline illuminated by in-transit visibility systems.

These data would feed models with the ability to recalculate the materiel demand and distribution for the entire Army at each instant. There are parallels today in the world of e-business, through companies like Amazon.com. Because we are forecasting demand, the models would be statistical in nature, designed to achieve a high probability of meeting priority needs.

The outputs would create unit-based sustainment packages and would also help manage global inventories, orders, shipments, and transportation.

Information Systems

- **Seamless battlefield distribution succeeds through highly effective C4ISR in the battle area, at theater, and beyond**
  - **Must have continual flows of information from maneuver forces to inform materiel distribution process**
  - **Dynamic times and locations for resupply operations**
- **Sustainment totally driven by information**
  - **Enhanced situational understanding thru C4ISR support to CSS**
  - **Systems like GCSS-A, CSS CS, MTS, and FBCB2 should link all echelons**
    - **Must be extended to the customer-- the FCS and the foxhole**
  - **Continuous, high-bandwidth data flows from the battle area**
  - **In-transit visibility illuminates the supply chain**

The achievement of seamless distribution on the battlefield is the result of many factors, including highly effective C4ISR systems. We must have continual flows of information from maneuver forces through theater and beyond to inform the materiel distribution process.

Army systems like GCSS-A, CSS CS, MTS, and others should expand to link all echelons. Today combat units are not part of the overall logistics system. And there must be continuous high-bandwidth available to support flows from the battle space.

Equally important is the capability of ITV systems to illuminate the supply chain and provide commanders confidence in the materiel distribution system.

APPENDIX A

TERMS OF REFERENCE

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY OF THE ARMY
ACQUISITION LOGISTICS AND TECHNOLOGY
103 ARMY PENTAGON
WASHINGTON DC 20310-0103

REPLY TO
ATTENTION OF

February 28, 2000

Mr. Michael J. Bayer
Chair, Army Science Board
2511 Jefferson Davis Highway, Suite 11500
Arlington, Virginia 22202

Dear Mr. Bayer:

I request that you conduct an Army Science Board (ASB) Summer Study on "Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era." The ASB members appointed should consider these Terms of Reference (TOR) as guidelines and may include in their discussions related issues deemed important or suggested by the sponsors. Modifications to the TOR must be coordinated with the ASB office.

I envisage that this work by the Army Science Board will also yield practical near term insights and opportunities that will assist the Army Leadership in focusing priorities for our limited research, development and acquisition accounts to create the most combat effective and cost efficient rapidly deployable joint ground forces for the 2015-2025 period.

The study should be composed of four parallel investigations leading to an integrated set of recommendations. This work is to be guided by, but not limited to, the following lines of inquiry:

Team 1 - Operations. To the goal of achieving rapidly deployable forces with dominant maneuver supported by precision fires, look at those opportunities which offer the greatest pay off for quickly deploying forces which feature a highly flexible array of full spectrum force capabilities. Focus on combat operations, accounting for capabilities required to achieve systems overmatch as a critical component of overall force effectiveness both for initial entry into a theater of operations and to enable operational maneuver within the theater once operations begin. The array of systems and force capabilities should assure future commanders retain battlefield freedom of maneuver and are not denied tactical options for offensive or defensive schemes of maneuver. While combat operations are the focus, the relevance of the capabilities to stability and support operations, such as peace operations, should be assessed. Consider, but do not limit your investigation to the following opportunities:

a. Look at the feasibility of synchronizing the requirements for the Future Combat System, the Joint Transport Rotorcraft (JTR), and Comanche to provide revolutionary tactical and theater mobility and increased strategic mobility. If feasible, what are the assumed tactical benefits of this union?

b. Assess the capabilities gained by exploiting robotic air and ground systems as reconnaissance/surveillance, attack systems, and other functions. Which force capabilities or platforms appear to benefit most from this relationship?

c. Propose a suite of smart munitions/sensor combinations in our direct fire and indirect fire forces that offer the most cost effective investment and the most decisive outcome in expected scenarios.

d. Determine those areas of the force that demand robust 24 hours a day, 7 days a week manning, and portray the benefits of various manning arrangements.

e. Identify the optimal organizational structures that best exploit future information technology.

f. Determine the need for or utility of an Advanced Theater Transport (ATT) to replace the C-130 to support the operational capability and systems described above.

Team 2 – Sustainment and Support. To the goal of providing this force a support/sustainment capability with significantly reduced logistic burden, look at the opportunities in providing forces with significantly greater systems reliability (including mechanical, electronic, photonic reliability, etc.) along with graceful degradation and ultrareliability leading to simplified battlefield maintenance, repair and diagnostics/prognostics (including disposable/expendable components/systems), significantly smaller fuel and ammunition tonnage requirements, improved battlefield medical support, transport means (manned and unmanned), and remote services. Consider, but do not limit your investigation to the following opportunities:

a. Assess the opportunities to leave outside the theater significant logistic, intelligence, and administrative support, thereby reducing the force requiring in-theater support.

b. Assess the opportunities for advanced power plants that reduce the specific fuel consumption at least 25% per HP delivered.

c. Assess the logistic implications of the alternative families of smart munitions (as generated by Team 1).

d. Exploit the opportunity for remote surgery (telemedicine) to reduce the number of in-country specialty surgeons.

e. Assess the capability of the JTR to contribute to rapid medical treatment and evacuation along with other joint force options.

f. Assess the opportunities to improve the Army's capability to conduct Near Shore/Logistics-Over-the-Shore operations.

Team 3 - Information Dominance. To the goal of providing this force Information Dominance through the provisioning of an advanced "central nervous system" to meet the needs of our forces and to deny the threat force basic information needs consider at least two perspectives. First is the broad, relatively global C4ISR focus that flows vertically from the Joint Task Force down through corps and divisions (as units of employment) all the way to units of action executing their tactical operations and tasks. The second perspective includes the time sensitive information at the local level that is dependent on rapidly changing battle command and control, "around the next hill/corner" situational awareness, and the needs at the tactical maneuver/support units and teams level - platforms and organic sensors centric. This assessment should consider both of these complementary perspectives. The objective of providing maneuver units a fundamental capability to expand their engagement envelopes to include short timeline, beyond line of sight and fleeting targets may provide a catalyst for this information dominance challenge. Look at capabilities which provide digital map location and terrain elevation data to support the needs of ground maneuver commanders and precision fires employment, yield superior situational awareness of friendly and threat forces, instantaneous critical logistic asset status and location, theater missile threat detection, location and ongoing tracking of any threat weapons of mass destruction, and deny the threat forces this basic capability using both lethal and non-lethal means. Provide forces with timely, reliable information updates (unit and platform level updates) to facilitate tactical and support mission planning and rehearsal during deployment and on the move. As technology opportunities are assessed, it is essential that future forces operating in urban and complex terrain environments have robust, high confidence situation awareness, across the full spectrum of military operations. Consider, but do not limit your investigation to the following opportunities.

a. Assess the suite of National and Theater sensors: overhead, air breathing, manned and robotic necessary to provide the desired data and information.

b. Assess the technological opportunity to provide necessary bandwidth for data, voice, and video requirements for the force.

c. Ascertain the requirements to deny the threat the necessary voice and data information he requires to effectively employ his forces.

d. Assess the ability to link all systems through an inter-netted system of non-line-of-sight communications.

Team 4 - Training. To the goal of ensuring that these deployed forces have an organic capability to train to peak effectiveness within the theater of operations, look at opportunities for providing embedded training devices for crew, team and small unit training; the ability to deliver training into the theater using "distance learning " opportunities; the ability to provide "mission rehearsal" capabilities as required; and the ability to permit staff and command training with sensitive intelligence products. These investigations should be grounded in a vision of a future training strategy for both collective and individual training which leverages a proper mix of live, virtual and constructive training and which is supported by an information based system of systems architecture. Consider, but do not limit your investigation to the following:

a. Assess the command and control systems' ability to provide necessary alternative mission analyses and threat scenario generation using all source intelligence.

b. Assess the opportunities for embedding necessary training system requirements in the Future Army Land and Aviation Vehicles, to include mission rehearsal capabilities. This assessment should include embedded joint training and real time cooperative training with units and systems both in and out of theater from alert through deployment and employment.

c. Assess the training requirements necessary to train the sensor to shooter precision fires employment.

d. Look at the need for and feasibility of using distance learning techniques to train portions of the force with out-of-Theater resources.

e. Investigate approaches which can link training and operational system capabilities to facilitate the creation of realistic conditions and which can store, fuse, filter and disseminate relevant information to a variety of training system components.

Study Support. Sponsors of this study are GEN John M. Keane, Vice Chief of Staff; GEN John N. Abrams, Commanding General, US Army Training and Doctrine Command; GEN John G. Coburn, Commanding General, Army Materiel Command, and LTG John J. Costello, Commanding General, Space and Missile Defense

Command. LTG Paul J. Kern is the ASA(ALT) cognizant deputy and LTG Randall L. Rigby, Jr., is the TRADOC cognizant deputy.

Schedule. The study panel will initiate the study immediately and conclude its effort at the report writing session to be conducted July 17-27, 2000, at the Beckman Center on the campus of the University of California, Irvine. As a first step, the study co-chairs will submit a study plan to the sponsors and the Executive Secretary outlining the study approach and schedule. A final report will be issued to the sponsors in September 2000.

Sincerely,

Paul J. Hoeper

Paul J. Hoeper
Assistant Secretary of the Army
(Acquisition, Logistics and Technology)

APPENDIX B

PARTICIPANTS LIST

PARTICIPANTS LIST

ARMY SCIENCE BOARD
2000 SUMMER STUDY

TECHNICAL AND TACTICAL OPPORTUNITIES FOR REVOLUTIONARY ADVANCES IN RAPIDLY DEPLOYABLE JOINT GROUND FORCES IN THE 2015-2025 ERA

Study Co-Chairs

Dr. Joseph V. Braddock
The Potomac Foundation

LTG Paul Funk (USA, Ret.)
General Dynamics Land Systems

Dr. Marygail Brauner
RAND

ASB Panel Chairs

The Operations Panel

Dr. Robert E. Douglas
Lockheed Martin Electronics and Missiles

LTG Daniel R. Schroeder (USA, Ret.)
Private Consultant

LtGen Paul K. Van Riper (USMC, Ret.)
Center for Naval Analyses

The Information Dominance Panel

Dr. Philip C. Dickinson
Private Consultant

LTG John W. Woodmansee (USA, Ret.)
Private Consultant

Gen James P. McCarthy (USAF, Ret.)
United States Air Force Academy

The Sustainment and Support Panel

Mr. Ed Brady
Strategic Perspectives, Inc.

GEN Leon E. Salomon (USA, Ret.)
Private Consultant

VADM William J. Hancock (USN, Ret.)
Hancock Associates

The Training Panel

Dr. Harold F. O'Neil, Jr.
University of Southern California

MG Charles F. Drenz (USA, Ret.)
C.F. Drenz & Associates, Inc.

RADM Fred L. Lewis (USN, Ret.)
National Training Systems Association

ASB Panel Members

The Operations Panel

Dr. Frank H. Akers
Lockheed Martin Energy Systems

Dr. Sheldon Baron
Baron Consulting

Dr. John Blair
JBX Technologies

Dr. Gregory H. Canavan
Los Alamos National Laboratory

Dr. Inder Chopra
University of Maryland

Dr. Herb Dobbs
TORVEC

Dr. Gilbert V. Herrera
Sandia National Laboratories

Dr. Anthony K. Hyder
University of Notre Dame

Mr. Ira F. Kuhn, Jr.
Directed Technologies, Inc.

Dr. Joanna T. Lau
Lau Technologies

LTG Charles Otstott (USA, Ret.)
Global InfoTek, Inc.

Mr. Srinivasan 'Raj' Rajagopal
United Defense

Dr. W. James Sarjeant
SUNY at Buffalo

Mr. George T. Singley
Hicks And Associates, Inc.

Dr. Tony Tether
The Sequoia Group

The Information Dominance Panel

Mr. John Cittadino
JCC Technology Associates

Dr. Derek Cheung
Rockwell Science Center

Ms. Christine Davis
Executive Consultant

Dr. James R. Fisher
DESE Research, Inc.

Mr. Jerome S. Gabig
The Time Domain Corporation

Ms. Dixie Garr
CISCO

Mr. Gary Glaser
LDCL, LLC

Dr. Lynn Gref
Jet Propulsion Laboratory

Dr. John Holzrichter
Lawrence Livermore National Laboratory

Ms. Suzanne Jenniches
Northrup Grumman Corporation

Dr. Don Kelly
Advantech Consulting

Mr. Kalle Kontson
IIT Research Institute

Mr. David Martinez
Massachusetts Institute of Technology

Dr. Rey Morales
Los Alamos National Laboratory

Dr. Prasanna Mulgaonkar
SRI International

Dr. Sam Musa
Northwestern University

Dr. James A. Myer
Photon Research Associates, Inc.

Dr. William Neal
The MITRE Corporation

Mr. John Reese
Private Consultant

Dr. Stuart Starr
The MITRE Corporation

Mr. Alan Schwartz
Policy Futures LLC

Dr. Nick Tredennick
Tredennick, Inc.

Dr. Robert Ziernicki
Mirage Systems, Inc.

The Sustainment and Support Panel

Mr. Buddy G. Beck
Thermo Washington

Mr. Anthony J. Braddock
The Loch Harbor Group, Inc.

Dr. David S. C. Chu
RAND Arroyo Center

Mr. William S. Crowder
Logistics Management Institute

Mr. John H. Gully
SAIC

Dr. Larry Gladney
University of Pennsylvania

Dr. Michael Krause
Freightdesk.com

Mr. Ray Leadabrand
Leadabrand and Associates

Mr. Paul Lumpkin
Plexus Scientific

Dr. Gary R. Nelson
SRA International

Mr. Donald R. ('Rob') Quartel
D.R. Quartel, Inc.

Dr. Joseph E. Rowe
Private Consultant

Dr. James S. Whang
AEPCO, Inc.

Dr. Annetta P. Watson
Lockheed Martin Energy Resources / ORNL

The Training Panel

MG Charles F. Drenz
C.F. Drenz and Associates

Dr. Charles Engle
ECC International

Mr. Frank Figueroa
Lockheed Martin/Sandia National Laboratories

Dr. Peter Lee
Carnegie Mellon University

Ms. Susan Lowenstam
Attorney

LTG John Miller (USA, Ret.)
Oracle

Dr. L. Warren Morrison
Carnegie Mellon University

Dr. Irene Peden
University of Washington

BG James Ralph (USA, Ret.)
Ralph Consulting LLC

Mr. Philip W. Spence
The McVey Company International

Staff Assistants

Operations Panel
Mr. Mike Hendricks
Logistics Integration Agency

Sustainment and Support Panel
CPT Dennis Gibson
Pennsylvania Army National Guard

Information Dominance Panel
Dr. Bert Smith
ODCSINT

Training Panel
Ms. Cherie Smith
PEO STAMIS

Sponsors

GEN John M. Keane
U.S. Army Vice Chief of Staff

GEN John N. Abrams
Commanding General
U.S. Army Training and Doctrine Command

GEN John G. Coburn
Commanding General
Army Materiel Command

LTG John J. Costello
Commanding General
Space and Missile Defense Command

MG Charles C. Cannon, Jr.
Acting DCSLOG

Cognizant Deputies

LTG Randall L. Rigby, Jr.
DCG, TRADOC

LTG Paul J. Kern
MILDEP to ASA(ALT)

Operations Panel Gov't Advisors

Brig Gen James Bankers
U.S. Air Force Reserve Command

Mr. Bob Dodd
TRADOC

BrigGen Donovan
U.S. Marine Corps Battle Lab

Dr. Jasper Lupo
Office of the Director of Defense Research and Engineering (Sensors and Electronics)

COL Mike Mehaffey
TRADOC

COL Kip Nygren
U.S. Military Academy

Maj Gen Paul Pochmara
DC Air National Guard

Mr. Earl Rubright
Headquarters, U.S. Central Command

Mr. Ralph Shaw
U.S. Army Reserve Command

Dr. Mike Sculley
U.S. Army AMCOM

Mr. H. Jack Taylor
Office of the Deputy Under Secretary of Defense (Acquisition, Technology and Logistics)

BG Jimmy Watson
Florida Army National Guard

Mr. Bruce Zimmerman
Office of the Assistant Secretary of the Army(Acquisition, Logistics and Technology)

Information Dominance Panel Gov't Advisors

Mr. Craig Baker
SMDC

Ms. Alita Farr
ODCSINT

Mr. Kurt Kovach
CECOM

LTC Jack Marin
U.S. Military Academy

Mr. Jeff Ozimek
CECOM

Dr. Bert Smith
ODCSINT

Mr. Paul Tilson
NRO

COL Ron Vandiver
TRADOC

LTC Keith Wooster
OCAR

Sustainment and Support Panel Gov't Advisors

LTC Gary Engel
USARC

BrigGen Feigley
USMC

MG Michael Gaw
USAR

LTC Matt Gorevin
TRANSCOM

Mr. Patrick Holder
TRADOC

Mr. Zbigniew Majchrzak
Deployment Process Modernization Office

COL Buck Mandville
TRADOC

COL Dan Roh
AMC

Mr. George Scherer
TRADOC

MG Walt Stewart
Pennsylvania Army National Guard

LTC(P) Dan Sulka
USA DLA

Mr. Tom Sweeney
Army War College

Mr. Mike Williams
MTMCTEA

Training Panel Gov't Advisors

CWO Doug Champion
CECOM

Dr. Mike Farmer
PM Distance Learning support contractor

Dr. Dexter Fletcher
Institute for Defense Analyses

MAJ Mike Freeman
Office of the Chief, Army Reserve

Dr. Stephen Goldberg
ARI

BrigGen Michael J. Haugen
North Dakota Air National Guard

Dr. Michael Macedonia
STRICOM

Mr. Thomas Moore
Logistics Integration Agency

COL David Raes
Iowa Army National Guard

COL Bob Reddy
TRADOC

Dr. Sandy Wentzel-Smith
U.S. Navy

Mr. Bob Whartenby
CECOM

Mr. Gary Winkler
PM Distance Learning

Dr. Wally Wulfeck
SPAWAR

APPENDIX C

ACRONYMS

Acronyms

A2C2	Army Airspace Command and Control
AAC	Army Acquisition Corps
AAE	Army Acquisition Executive
AAFIF	Automated Air Facilities Information File
AARs	After Action Reviews
ABCS	Army Battle Command Systems
ABN	Airborne
ACAT	Acquisition Category
ACOM	Atlantic Command
ACR	Armored Cavalry Regiment
ACTD	Advanced Concept Technology Demonstration
ADO	Army Digitization Office
AEF	Air Expeditionary Force
AF	Air Force
AFSAB	Air Force Scientific Advisory Board
AFSS	Advanced Fire Support System
AJ	Anti Jamming
AGCCS	Army Global Command and Control System
AGS	Armored Gun System
AI	Artificial Intelligence
ALP	Advanced Logistics Project
AMC	Army Materiel Command
AMCOM	Aviation and Missile Command
AMSAA	Army Materiel Systems Analysis Activity
AOR	Area of Responsibility
APFSDS	Armor-Piercing, Fin-stabilized, Discarding Sabot
APC	Armored Personnel Carrier
APOD	Aerial Port of Debarkation
APOE	Aerial Port of Embarkation
APS	Active Protection Systems; Army Prepositioned Stocks
ARDEC	Army Research, Development, and Engineering Center
ARL	Army Research Laboratory
ATT	Advanced Tactical Transport
ARTY	Artillery
ASA(ALT)	Assistant Secretary of the Army for Acquisition Logistics and Technology
ASB	Army Science Board
ASD C3I or ASD(C3I)	Assistant Secretary of Defense (Command, Control, Communications, and Intelligence)
ASTMP	Army Science and Technology Master Plan
ASTWG	Army Science and Technology Working Group
AT	Anti Tank
ATD	Advanced Technology Demonstration
ATG	Anti-Tank Gun

ATGM	Anti-Tank Guided Missile
ATR	Automated Target Recognition
AWE	Advanced Warfighting Experiment
B2C2	Battalion and Below Command and Control
BAT	Brilliant Anti-Tank
BCIS	Battlefield Combat Identification System
BDA	Battle Damage Assessment
BDE	Brigade
BITS	Battlefield Information Transmission System
BLOS	Beyond Line of Sight
BN	Battalion
C2	Command and Control
C2E	Command Center Element
C2OTM	Command and Control On-The-Move
C2SID	Command and Control System Integration Directorate
C2T2	Commercial Communications Technology Testbed
C2V	Command and Control Vehicle
C2W	Command and Control Warfare
C3	Command, Control and Communications
C3I	Command, Control, Communications and Intelligence
C3IEW	Command, Control, Communications Intelligence and Electronic Warfare
C4	Command, Control, Communications and Computers
C4I	Command, Control, Communications, Computers and Intelligence
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CASCOM	Combined Arms Support Command
CASTFOREM	Combined Arms and Support Task Force Evaluation Model
CBW	Chemical and Biological Warfare
CC&D	Concealment Camouflage and Deception
CDR	Critical Design Review
CDT	Commercially Driven Technologies
CE	Chemical Energy
CECOM	Army Communication-Electronics Command
CHP	Controlled Humidity Preservation
CINC	Commander-in-Chief
CINCTRANS	Commander-in-Chief, Transportation Command
CKEM	Compact Kinetic Energy Missile
CM	Countermeasures
CONOPS	Concept of Operations
CONUS	Continental United States
COA	Course of Action
COTS	Commercial Off-The-Shelf
CPX	Command Post Exercise

CRAF	Civil Reserve Air Fleet
CSA	Chief of Staff, Army
CSSCS	Combat Service Support Computer System
CTC	Combat Training Center
DARPA	Defense Advanced Research Projects Agency
DAS	Director of Army Staff
DAS(R&T)	Deputy Assistant Secretary for Research and Technology
DBBL	Dismounted Battlespace Battle Lab
DCS(RDA)	Deputy Chief of Staff Research Development and Acquisition
DCSD	Deputy Chief of Staff Combat Development
DCSDOC	Deputy Chief of Staff Doctrine
DCSINT	Deputy Chief of Staff Intelligence
DCSLOG	Deputy Chief of Staff Logistics
DCSOPS	Deputy Chief of Staff Operations
DDR&E	Director, Defense Research and Engineering
DE	Directed Energy
DEW	Directed Energy Weapons
DISA	Defense Information Systems Agency
DISC4	Director, Information Systems, Command, Control, Communications and Computers
DL	Distance Learning
DLA	Defense Logistics Agency
DMSO	Defense Modeling and Simulation Office
DoT	Department of Transportation
DPG	Defense Planning Guide
DPICM	Dual Purpose Improved Conventional Munitions
DS	Direct Support
DSB	Defense Science Board
DSWA	Defense Special Weapons Agency
DSP	Digital Signal Processing
DTAP	Defense Technology Area Plan
DTLOMS	Doctrine, Training, Leader Development, Organization, Materiel, and Soldiers
DTO	Defense Technology Objective
DU	Depleted Uranium
DUSA-OR	Deputy Undersecretary of the Army - Operations Research
EAD	Echelons Above Division
EFOGM	Enhanced Fiber-Optic Guided Missile
EFP	Explosively Formed Penetrator
ELINT	Electronic Intelligence
EM	Electro-Mechanical, Electro-Magnetic
EMD	Engineering and Manufacturing Development
EML	Electro-Magnetic Launch
EMPRS	En Route Mission Planning and Rehearsal System

EO/IR	Electro-Optical/Infrared
ERA	Extended Range Artillery, Explosively Reactive Armor
ETC	Electro-Thermal Chemical
EW	Electronic Warfare
F&M	Firepower and Mobility
FBCB2	Force XXI Battle Command Brigade and Below
FC	Fire Control
FCS	Fire Control Systems; Future Combat System
FCV	Future Combat Vehicle
FCVT	FCV Team
FLIR	Forward Looking Infra-Red
FOB	Forward Operating Base
FOG-M	Fiber-Optic Guided Missile
FORSCOM	Forces Command
FTR	Future Transport Rotorcraft
FSCS	Future Scout and Cavalry System
FSV	Future Scout Vehicle
FTX	Field Training Exercise
GCCS	Global Command and Control System
GCSS	Global Combat Support System
GCSS-A	Global Combat Support System – Army
GIG	Global Information Grid
GIS	Global Information System
GOSC	General Officer Steering Committee
GPS	Global Positioning System
GVW	Gross Vehicle Weight
HE	High Explosive
HEAT	High Explosive Anti-Tank
HHH	Hand-Held Heat
HIMARS	High Mobility Artillery Rocket System
HMMWV	High Mobility Multi-purpose Wheeled Vehicle
HNS	Host Nation Support
HPM	High Power Microwave
HQAMC	Headquarters of the Army Materiel Command
HSS	High-Speed Shipping
HVAP	High Velocity Armor Penetrating
I2R	Imaging Infrared
IA/IW	Information Assurance/Information Warfare
ICM	Improved Capabilities Missile, Improved Capabilities Munitions
IFSAR	Interferometric Synthetic Aperture Radar
III	Integrated Information Infrastructure(s)
IO	Information Operations

IPT	Integrated Product Team
IR	Infra Red
IR&D	Independent Research and Development
ISC/R	Individual Soldier's Computer/Radio
ISR	Intelligence Surveillance Reconnaissance
IT	Information Technology
IW	Information Warfare
IWS	Individual Warfighter System
J3	Operations Directorate, Joint Staff
J4	Logistics Directorate, Joint Staff
JCF	Joint Contingency Force
JCS	Joint Chiefs of Staff
JIT	Just-in-Time
JOPES	Joint Operation Planning and Execution System
JROC	Joint Requirements Oversight Council
JS	Joint Support, Joint Staff
JSTARS	Joint Surveillance Target Attack Radar System
JTA	Joint Technology Architecture(s)
JWCA	Joint Warfighting Capability Assessment
KE	Kinetic Energy
KE/CE	Kinetic Energy / Chemical Energy
KEM	Kinetic Energy Missile
LAM	Land Attack Missile
LADAR	Laser Radar
LAV	Light Armored Vehicle
LAW	Light Anti-tank Weapon
LCLO	Low Cost Low Observable
LCMS	Laser Counter Measures System
LCPK	Low Cost Precision Kill
LIDAR	Light Detection and Ranging
LIWA	Land Information Warfare Activity
LLNL	Lawrence Livermore National Laboratory
LMSR	Large Medium Speed Roll-on/roll-off
LO	Low Observables
LOS	Line of Sight
LOSAT	Line-of-Sight Anti-Tank
LOTS	Logistics Over-the-Shore
LPD	Low Probability of Detection
LPI	Low Probability of Intercept
LRIP	Low Rate Initial Production
LTL	Less-than-Lethal
LW	Land Warrior

M&S	Modeling and Simulation
MAGTF	Marine Air-Ground Task Force
MANPADS	Man-portable Air Defense System
MANPRINT	Manpower and Personnel Integration
MAVs	Micro-Autonomous Vehicles, Micro Air Vehicles
MEM	Micro-Electro-Mechanics
MEMS	Micro Electric Mechanical System
MEP	Mobile Electric Power; Mission Equipment Package
METT-T	Mission, Enemy, Troops, Terrain, Time
MEU	Marine Epeditionary Unit
MHE	Materiel Handling Equipment
MILDEP	Military Deputy
MLRS	Multiple Launch Rocket System
MMCS	Multi-Mission Combat System
MMUAV	Multi-Mission Unmanned Air Vehicle
MNS	Mission Needs Statement
MOUT	Military Operations in Urban Terrain
MPIM	Multipurpose Infantry Munition
MPS	Maritime Prepositioning Ship
MRDEC	Missile Research, Development and Engineering Center
MSTAR	Moving and Stationary Target Acquisition and Recognition
MTI	Moving Target Indicator
MTI-SAR	Moving Target Indicator – Synthetic Aperture Radar
MTMC	Military Transportation Management Command
MTMC-TEA	Military Transportation Management Command – Transportation Engineering Agency
MVMT	Movement
MW	Mounted Warrior
NBC	Nuclear, Biological and Chemical
NDF	National Defense Features
NG APS	National Guard - Army Prepositioned Stocks
NGB	National Guard Bureau
NGIC	National Ground Intelligence Center
NL	Non-Lethal
NLT	No Later Than
NLW	Non-Lethal Weapons
NMD	National Missile Defense
NRAC	Naval Research Advisory Committee
NRDEC	Natick Research, Development and Engineering Center
NSA	National Security Agency
NTC	National Training Center
NVESD	Night-Vision/Electronic Sensors Directorate
O&O	Operational and Organizational
OCAR	Office of the Chief, Army Reserve

OCONUS	Outside Continental United States
ODCSOPS	Office of the Deputy Chief of Staff for Operations
OOTW	Operations Other Than War
OPM	Other People's Money
ORD	Operational Requirements Document
OSD	Office of the Secretary of Defense
P3I	Preplanned Product Improvement
PAM	Precision Attack Munitions
PDR	Preliminary Design Review
PDRR	Program Definition/Risk Reduction
PEO	Program Executive Office (Officer)
PEO/3C	Program Executive Officer for Command, Control and Communications
PGM	Precision Guided Munitions
PGMM	Precision Guided Mortar Munitions
POD	Point of Debarkation
POL	Petroleum, Oil and Lubricants
POM	Proparation for Overseas Movement
POS/NAV	Position/Navigation
PREPO	pre-positioned stocks
RHA	Rolled Homogenous Armor
RHAE	Rolled Homogenous Armor Equivalent
R/S	Reconnaissance/Surveillance
RC	Reserve Component
RDA	Research Development and Acquisition
RDT&E	Research Development Testing and Evaluation
RFPI	Rapid Force Projection Initiative
RHA	Rolled Homogenous Armor
RORO	Roll-on Roll-off
RPG	Rocket Propelled Grenade
RRF	Rapid Reaction Forces
RSTA	Reconnaissance Surveillance, Target Acquisition
S&T	Science and Technology
SA	Situation Awareness
SAALT	Secretary of the Army for Acquisition, Logistics and Technology
SACLOS	Semi-Automated Line of Sight
SADARM	Sense and Destroy Armor
SAR	Synthetic Aperture Radar
SARDA	Secretary of the Army for Research Development and Acquisition – outdated, now SAALT – Secretary of the Army for Acquisition, Logistics and Technology
SAS	Situation Awareness System
SBIR	Small Business Innovation Research

SES	Surface Effect Ships
SIGINT	Signal Intelligence
SIMNET	Simulation Network
SINCGARS	Single Channel Ground and Airborne Radio System
SIPE	Soldier Integrated Protective Ensemble
SLAD	Survivability and Lethality Directorate
SLID	Simple Low-cost Interception Device
SM	Signature Management
SRO	Strategic Research Objective
SSCOM	Soldier Systems Command
SSTOL	Super Short Take-Off & Landing
STARC	State Area Command
STI	Stationary Target Indicator
STO	Science and Technology Objective
STOW-E	Synthetic Theater of War-Europe
SUO	Small Unit Operations
SUOSAS	Small Unit Operations Situation Awareness System
SUSOPS	Sustained Operations
SWA	South West Asia
T&E	Test and Evaluation
TAA	Tactical Assembly Area
TAAD	Theater Area Air Defense
TACOM	Tank Automotive and Armaments Command
TAP	Technology Area Plan
TARA	Technology Area Review and Assessment
TARDEC	Tank Automotive Research Development and Engineering Center
TDA	Table of Distribution and Allowances
TENCAP	Tactical Exploitation of National Capabilities (program)
TERM	Tank Extended Range Munitions
TES	Tactical Engagement System; Tactical Engagement Simulation
TEU	20-foot-equivalent unit
TF	Task Force
THAAD	Theater High Altitude Defense System
TOC	Tactical Operations Center
TOR	Terms of Reference
TOW	Tube-Launched, Optically Tracked, Wire Command-Linked Guided
TPFDD	time-phased forces deployment data
TRADOC	Training and Doctrine Command
TRANSCOM	Transportation Command
TTP	Tactics, Techniques, and Procedures
TWG	Technology Working Group
TWS	Thermal Weapon Sight
UAV	Unmanned Aerial Vehicles
UGS	Unattended Ground Sensors

UGV	Unmanned Ground Vehicles
UHF	Ultra-High Frequency
USMA	United States Military Academy
USMC	United States Marine Corps
UV	Ultra-Violet
UWB	Ultra-Wide Band
UXO	Unexploded Ordinance
V/STOL	Vertical or Short Take-off and Landing
VCSA	Vice Chief of Staff of the Army
VISA	Voluntary Intermodal Shipping Agreement
VSAT	Very Small Aperture Terminal
VTOL	Vertical Take-off and Landing
VTOL JTR	Vertical Take-off and Landing – Joint Tilt Rotor
WARSIM	Warfighter Simulation
WIN	Warfighter Information Network
WMD	Weapons of Mass Destruction
WRAP	Warfighting Rapid Acquisition Program

For Acronyms not found here, consult:

http://www.adtdl.army.mil/atdl/search/acronym.htm
or
http://www.sew-lexicon.com/

APPENDIX D

DEPLOYMENT

THE LAST THOUSAND YARDS

Army Science Board 2000 Summer Study

Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era

Support and Sustainment Panel, Deployment Sub-Panel

Assured Access – The Last 1000 Yards

<u>Sub-Panel Members</u>

MG Michael Gaw
COL Gary Engel
LTC Matthew Gorevin
Mr. William Crowder
Mr. Zbigniew Majchrzak
Mr. Bryan Reyns
Mr. Thomas Sweeney

> "With the right technological solutions, …[deploy] a combat capable brigade anywhere in the world in 96 hours once we have received execute liftoff, a division on the ground in 120 hours, and five divisions in 30 days."
>
> General Shinseki's AUSA Eisenhower Speech, October 1999.

Executive Summary

The Deployment Sub-panel's focus, "Assured Access," was adapted from the Army Science Board's study topic — "Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era."

Deployment and "the Last 1000 Yards"

Force closure is a function of three variables: the movement requirements, the distance the requirements must be moved, and finally, the capabilities to move (and throughput) the requirements. Closing the force faster can be accomplished by increasing capabilities (lift and throughput), decreasing movement requirements (reducing logistics and lightening the force), shortening the movement distance, or a combination of the three. This sub-panel looked at ways to increase capabilities, and thus speed force closure.

We continued the work begun on the 1999 ASB study, "Strategic Maneuver," and focused on an aspect that warrants further attention. Last year's ASB study considered the entire force projection process; we focused on assured access into the "last 1000 yards." We define assured access as the ability to project combat power to the fight even if infrastructure and resources are limited or nonexistent, air and sea ports are denied or degraded through enemy anti-access measures, or geographic features and political constraints create obstacles to force closure.

Why is assured access the critical link? Simply put, it is the most difficult piece of the deployment process. Assured access, however, has not had the effort devoted to it that the first "10,000 miles" of deployment has. Last year's ASB study recommended several methods to improve deployment (deployment command and control, information technology, leveraging commercial lift, basing concepts). Most of the recommendations addressed the entire force projection process, and while the study recognized the need for assured access, it did not identify specific technological enablers.

We wanted to identify the technologies that will enable the Army to deliver combat forces, ready to fight, even if fixed facilities are unavailable, inadequate, degraded, or denied.

Findings

Several DOD and non-DOD sources briefed our panel regarding technological enablers for assured access. As we heard these concepts, we found that while force projection in general, and assured access in particular, is being addressed to some degree in small, disjointed efforts, there is no concerted effort in these areas. Further investigation showed that there does not appear to be a central figure who is directing,

controlling, coordinating, and resourcing the R&D efforts — in effect, there is no champion for this area.

From our continued research of S&T/R&D literature, we found that despite the implicit importance of assured access, there is relatively little effort regarding force projection in the S&T/R&D documents. Bottom line: we speak a great deal of rapid force projection and assured access, but we do not devote the effort necessary to identify and develop the technological enablers that will ensure the Army's deployment timelines are met. The scarce resources that are available seem to be diluted among disparate efforts.

Further, we found many efforts underway that have not been given adequate attention, have had inadequate funding, or lack significant payoff. Many have been ongoing for years. For example, the Rapidly Installed Breakwater System (a sea state mitigator) has been under study since 1975. With R&D resources scarce, and from the standpoint of good stewardship, we feel the efforts should either be focused to bring the capabilities to fruition or cancelled to avoid expenditure of unnecessary resources.

Recommendations

Force projection is an absolute necessity for Army Transformation. Without the ability to project forces rapidly, and to assure access to theater, the rest of the Army Transformation is moot—We are, indeed, a force projection Army. Owing to the centrality of force projection to Army Transformation, a harmonizer, prioritizer, and focuser of R&D efforts is essential—and that responsibility should rest with the DCSOPS. Within the body of this report, we discuss in more detail the responsibilities for this force projection champion and identify several promising technological enablers that address the requirement for assured access.

Assured Access: "The Last 1000 Yards"

The Army has committed tremendous resources to address strategic mobility for the first "10,000 miles" of the deployment process such as the Army Strategic Mobility Program (ASMP), infrastructure improvements, prepositioned stocks, and other enablers. However, the final delivery phase into a theater of operations, the "last 1000 yards," has continued to present significant difficulties for force projection operations. The last 1000 yards represents the critical link or seam between strategic lift and actual, assured entry into the theater of operations. Strategic maneuver must incorporate the ability to assure the access of our future rapid projection force into any future theater of operations. The concept of assured access is not new; today we have limited airdrop and Joint Logistics Over The Shore (JLOTS) capabilities. Recent deployments, such as those into Somalia and Albania, highlight the fact that we have yet to solve the problem of assured access. Clearly, this force projection weakness must be addressed in order to ensure rapid, early, and continuous entry into any theater of operations.

Last year's Army Science Board Study, "Strategic Maneuver," addressed the force deployment implications of an enemy "anti-access" capability, and how the Army might counter threat actions and options. This sub-panel continues that work and focuses on a subset of last year's effort—what we call "the last 1000 yards," the seam between strategic and tactical modes. This seam could be in any of several locations--a bare beach in a JLOTS operation, a degraded port facility, an airfield, or an Intermediate Staging Base (ISB).

Historically, the limiting factor regarding deployment timelines and force projection has been the throughput capabilities of theater reception facilities. This problem is exacerbated if inadequate facilities exist in the area of operations or fixed facilities are degraded due to enemy actions. Clearly, Aerial Ports Of Debarkation (APODs) and Sea Ports of Debarkation (SPODs) are predictable entry points which future adversaries will target in an attempt to impede our ability to project combat power. It should also be expected that an enemy will use asymmetric measures against such targets to counter US momentum, seeking to gain time for positional advantage.

Assumptions

Before we began to explore ways to close the last 1000 yards, we made several assumptions to narrow the scope of our effort. First, we assumed that the Large Medium Speed Roll-on/Roll-off (LMSR) ships would still be the surge sealift vessels, afloat prepositioned equipment would be aboard some number of LMSRs, the Fast Sealift Ships (FSS) would still be in the fleet, and that the Ready Reserve Force (RRF) would be in existence in some state, as new ships are brought in and others retired. The Voluntary Intermodal Sealift Agreement (VISA) would continue to provide commercial sealift. Next, we assumed that the C-17 would still be the primary strategic airlifter and that Civil Reserve Air Fleet (CRAF) policies would still be in place that restrict CRAF from flying into unsecured areas. We further assumed that future Army equipment would be designed to fit in a common envelope (similar to the Future Combat System (FCS) requirement that it fit in a C-130 with a 1000-mile leg). In addition, the Army airlift requirements will continue to be early in the deployment timeline and will compete with

other service early entry deployment requirements. Finally, we assumed that future Commander-in-Chief (CINC) plans will require forces in a compressed timeline and that these plans will show a need for assured access for all service components. CINC lift allocations will likely remain nearly the same as today, but the Army will require more and earlier airlift in the deployment process. For longer term sustainment, the Army will use roughly the same percentages as today (90% sea, 10% air).

During the course of this study we focused on systems and concepts that are being proposed to address some of the difficulties regarding deployment and assured theater entry. It is critical that we maximize throughput at SPODs, APODs, and austere points of entry to assure rapid force projection in the future. Employing an intermodal system of systems approach that is virtually seamless throughout the force projection process will help to maximize this throughput. Inter- and intratheater transport can be enhanced by shallow draft, high speed sealift (SDHSS). This sealift also supports the use of an ISB transportation hub located outside of the theater which minimizes the reliance on the fixed SPODs and APODs. Currently, these and other efforts are being addressed in an uncoordinated, piecemeal fashion without regard to system contribution and highest payoffs.

The future Army must be able to project combat power to the fight, and access must be assured into a theater of operations across the entire operational spectrum. Delivery of combat power into a future theater of operations through fixed, improved existing facilities is the preferred means of achieving deployment over the last 1000 yards. Multiple modes for entry must be employed or available for employment, however, especially when functioning under austere conditions. These deployments must incorporate seamless multi-modal, intermodal means of delivery using best practices available in both the future commercial and military capabilities. Delivery systems and techniques must be developed in a focused manner to ensure entry of combat power into unimproved facilities through both air and sea delivery. Combat power must be delivered "ready to fight" with extremely limited effort required to accomplish Reception, Staging, Onward Movement, and Integration (RSOI) of forces in theater. In fact, the RSOI may take place at home station, allowing for direct entry into combat.

Anti-Access Strategies

The 1999 ASB study recognized that a thinking adversary will seek to deny our forces access to the theater. Future adversaries will employ all available resources to deny our ability to achieve force closure in a timely manner. The last 1000 yards into the theater, regardless of the mode of transport in the deployment process, is the easiest point for a thinking adversary to disrupt deployment operations. In addition to traditional choke points, a thinking enemy will disrupt operations especially where friendly resources are limited. This factor is especially true during the arrival phase of entry operations. SPODs and APODs could be in enemy hands or their use for entry could be denied in other ways such as the employment of Weapons of Mass Destruction (WMD).

The Army After Next Spring War Game in 1999 demonstrated the impact a thinking enemy could have upon our deployment operations. During the exercise, the Red Force launched coordinated attacks on SPODs, APODs, and pipeline facilities (primarily pumping stations) to degrade Blue Force support and sustainment operations. Because the Red Force was denied adequate reconnaissance information of the battle

space, they identified targets of opportunity simply by employing an understanding of American logistical doctrine and by marking targets based on map reconnaissance. These attacks employed chemical and conventional munitions delivered by inexpensive cruise missiles that are readily available in today's world market. The prospects for the future are likely to be even more challenging. The assessment team measured a degradation of Blue Force support capabilities by 70 percent as a result of the Red Force action. This action directly inhibited the ability of the Blue force to continue offensive operations in support of the National Objectives.

The Blue Forces were forced to begin support operations from various ISBs, which are normally operated as transportation and cargo transfer locations, positioned outside of the theater. The Blue force was severely hampered in execution of its mission because of the limited ability of the Blue force to project combat power into the theater of operations under the resultant austere entry conditions. Transportation systems and organizations were not properly resourced with flexible capabilities to ensure entry given such operational conditions.

The May 2000 Army Transformation Wargame found the Red side specifically targeting infrastructure and resources supporting Blue force projection.

The Air Force conducted Global Engagement V, in June, 2000. In this game the Red force conducted an aggressive anti-access campaign which slowed Blue's deployment, required massive dispersal in the objective area, and was done without resorting to WMD.

Findings on Research and Development:

While there is an inextricable link between deployment and employment, there is no real link between force projection R&D and maneuver R&D to optimize force projection. There have been a variety of efforts over the past 30 years, but these have lacked focus, have not been synchronized to produce useful materiel solutions, and have not provided an effective match between the desired end state of strategic responsiveness and the enabling means. Most importantly, they are not supportive of the needs of Army Transformation.

R&D History

The Army has a very weak record when it comes to R&D for the problem of the "last 1000 yards." We recognized the problem of assured access in the modern environment prior to 1970. For example, early efforts to provide the means to deliver containers in an austere environment began with the Offshore Discharge of Containerships (OSDOC) in 1970. That early test identified such problems as sea state, motion control, deployable support craft such as causeways, soil stabilization and trafficability, and the use of helicopters to bring containers ashore. For thirty years we have been paying lip service in the R&D arena to these problems (see Table 1). We have continued year after year to provide minimal funds to a variety of programs. None has advanced very far. Yet each year some small set of programs continues.

There is no focus to this R&D effort. There has not been any in-depth examination of the likelihood of success for given R&D approaches. For example, if the

ability to operate in Sea State 3 is a requirement (and it has been since 1970), what technology offers the most promise? Which method offers the best technical and operational payoff? Is it the method which attempts to dampen the motion of the water -- such as portable breakwaters? Is it the investigation of compensating devices on the cranes and other discharge platforms to nullify the impact of sea state on the platforms themselves? Or is it some other methodology altogether?

<u>Current R&D Efforts</u>

We have a 30-year record of very minimal and unproductive research and development. Perhaps it is a question of funding. Perhaps we have never put adequate resources into any project to bring the research to a definitive state. But it is also a question of focus and priority. We have not marshalled the R&D resources to attack intensively any one problem or another. And we really don't know which problem is most pressing. We don't have a commitment to resolution of the access problem at austere seaports and airfields.

We need to focus our efforts by assessing the technologies which offer the best promise, and we need to support them. We also need to abandon many of the low level, unproductive efforts, which, so far, have only drained important resources from meaningful solutions.

Our literature is full of examples that cite the need for R&D efforts for force projection. Emerging operational concepts, both joint and service, require rapid force projection and assured access, and the technology investments to achieve them. Joint Vision 2020 calls for the "ability to rapidly project power worldwide in order to achieve full spectrum dominance," and states that "attaining [full spectrum dominance] requires the steady infusion of new technology and modernization and replacement of equipment." The Defense Science and Technology Strategy calls for a 21st century Army that is dominant across the full spectrum of operations and is "more strategically responsive…than today's force."

Specifically, meeting the Army's Objective Force deployment timelines (a combat brigade anywhere in the world in 96 hours; put a division on the ground in 120 hours; and five divisions on the ground in theater in 30 days) will require a significant Science and Technology investment.

The Joint community recognizes the need as well. In fact, USTRANSCOM's Strategic Guidance (currently in draft) states that "the DOD Research and Development (R&D) communities do not adequately invest advanced research into the evolutionary and revolutionary transportation technologies that will enhance our capabilities to efficiently and effectively project the future force." Further, a strategic objective for USTRANSCOM is to exercise a recognized role in shaping DOD R&D efforts to support future transportation requirements.

Unfortunately, despite the stated need for rapid strategic responsiveness, our panel was unable to find a corresponding match between the desired end state (strategic responsiveness) and the enabling means (science and technology investments). For example, the 2000 version of the Defense Science and Technology Strategy makes no mention of force projection, deployment, or rapid delivery of combat forces—the very things that JV2020 state that US forces must have to achieve its goal of Full Spectrum Dominance.

The Joint Warfighting Science and Technology Plan (JWSTP) contains two Joint Warfighting Capability Objectives that pertain to force projection—Dominant Maneuver/Force Projection, and Real-Time Focused Logistics. Yet a review of the technology plans designed to enable these objectives shows only a very cursory effort dedicated to force projection and assured access.

Finally, the Army Science and Technology Master Plan (ASTMP) recognizes that "to project the force the logistics community needs key information technologies that rapidly and automatically identify and track assets, access to and use of theater entry technologies such as battlefield visualization and situational awareness, advanced thermodynamic material for unattended, tamper–proof, climatically controlled "smart" containers, and access to and use of theater command and control technologies." Notice that assured access enablers are not mentioned.

It was equally difficult to find force projection as a key element of any Advanced Concepts and Technology Demonstrations (ACTD), Advanced Technology Demonstrations (ATD), or Scientific and Technical Objectives (STO).

Areas of R&D Exploration

During the course of this study we focused on systems and concepts that are being proposed that help to address some of the difficulties regarding deployment and assured theater entry. There were four areas we addressed that appeared, based upon the 1999 ASB study, as critical weaknesses in our force projection capabilities.

It has become readily apparent that we must employ an intermodal system of systems approach that is virtually seamless throughout the force projection process. It is critical that we maximize throughput at SPODs, APODs, and austere points of entry to assure rapid force projection in the future. There are numerous promising enablers such as adaptable containers with tactical equipment designed with throughput features of intermodal cargo designs incorporated within the systems. As we search for solutions to our force projection challenges, we must not overlook the importance of transportability. This is the inherent capability of materiel to be moved effectively and efficiently by transportation assets. In essence it is ensuring that the physical attributes of an individual piece of equipment do not preclude it from being moved by the required transport modes, whether that be by truck, railcar, ship, airplane, or container.

Intratheater transport via high speed, shallow draft sealift provides an essential resource as well as supporting the ISB transportation hub located outside of the theater which will also minimize the reliance on the fixed SPODs and APODs. Currently, all of these and other efforts are being addressed in an uncoordinated, piecemeal fashion without prioritization towards the most efficient systems improvements.

The future force projection Army must possess the ability to deliver combat power from ships to shore locations without fixed facilities. Operational requirements will drive sea state limitations and limitations of sea state capabilities will mitigate operational requirements such as the recent experience of discharging cargo into Mogadishu. Historically, we have focused on mitigation of sea states to ensure adequate discharge of cargo through operations such as JLOTS. However, it may prove more practical to stabilize our deployment platforms than to control the sea. We also explored various concepts such as causeway systems, high speed, shallow draft intratheater sealift,

and improving cross-beach capabilities. All of the various proposed enablers incur a resource cost such as capacity, forces, equipment, and time.

Not only must we possess the capability to deliver cargo to other than fixed ports of debarkation, we must also be able to deliver forces and sustainment to austere locations without material handling equipment. Enablers such as super-short take-off and landing aircraft, vertical take-off and landing delivery platforms, robotic delivery systems, and precision air drop were concepts we explored. In our opinion, a thinking adversary will deny our access to fixed facilities, forcing us to develop alternative entry capabilities.

Communications within the force projection community must be adequate and compatible with both tactical and commercial communication systems. This factor is essential to assure visibility, accountability, and efficient employment of limited deployment assets. Further, this will enable dynamic planning and execution through the use of logistics deployment support tools with equal precedence coordinated with combat force planning capabilities. Robust logistics communications capability netted with combat systems and civilian resources are essential for maximization of force projection operations into any theater.

<u>Force Projection Is An Operational Imperative</u>

Force Projection and the capabilities that it calls for are the central elements of Strategic Maneuver. Strategic Maneuver is the ability to project military power rapidly from all points of the globe and to converge simultaneously with overwhelming land air, space, and maritime forces which paralyzes the enemy and begins the process of psychological domination. The objective is to wrest the operational initiative, achieve dominance, terminate the conflict or set the conditions for rapid success of follow-on campaign forces. In looking closely at the definition of strategic maneuver, two points need to be emphasized: That strategic maneuver is larger than logistics, making it an operational concern, and that it is larger than the Army, making it part of a joint effort.

The proponent for force projection and its support of strategic maneuver must be the DCSOPS, who can lead the prioritization, harmonization, and focus for the force projection R&D efforts and for the development of requirements.

The Army, through the DCSOPS, must also be able to sell its requirements to the Joint Community, by having them addressed in the JWCA and JROC processes. Army efforts must be coordinated with and supported by the joint community.

<u>Recommendations:</u>

We believe the Department of the Army Deputy Chief of Staff for Operations and Plans should be designated to harmonize, prioritize, and focus force projection Research and Develop (R&D) efforts and requirements. Assured access, an essential aspect of the Joint Warfighting Capability Objectives (Dominant Maneuver/Force Projection) must have a champion for its R&D needs. This "champion" could serve as the clearing organization tasked with submitting requirements into the Joint arena on behalf of Force Projection support including Title 10 requirements to other Services. Army force

projection will only become a reality when the goal is accomplished through a centrally focused, coordinated, and prioritized systematic approach.

Promising Technologies

There are a number of promising approaches that warrant further analysis that could serve as future enablers for force projection. Some of these promising concepts are:

1. Shallow-draft high-speed ships. Of all lift assets, shallow-draft high-speed ships (SDHSS) appear to have the most significant impact on assured access. It is the only strategic platform that can deliver troops and equipment together in sufficient size to bring immediate combat power. While traveling, commanders have an opportunity to conduct enroute planning and receive intelligence updates. Moreover, the SDHSS do not require a fixed port because they can discharge combat power wherever there is a ten-foot draft and an acceptable beach gradient -- consequently they can enable surprise and thwart enemy anti-access strategies. Naval architecture has been a very conservative field, and especially so within the military. There are a number of proposals in the commercial market which show promise and demonstrate the likelihood of achieving speeds and tonnage capabilities far in excess of our traditional upper limit of 40 knots. These promising technologies deserve a vigorous and rapid examination with the goal of advancing the most promising capabilities along very quickly. We need some creative partnering to explore these capabilities and we need to push the limits as soon as possible.

2. Transportation Automated Measurement System. TrAMS combines weigh-in motion, profilometry, and electronic data interchange technologies. TrAMS will weigh and measure wheeled vehicles and automatically calculate center of balance for load planning. It will reduce loading times, allow for more optimal lift asset utilization, and enhance in-transit visibility.

3. Super-Short Take-Off and Landing Aircraft. The value of the SSTOL is its ability to land and take-off nearly vertically -- on a runway or 750-foot road length -- and deliver combat vehicles to unpredictable Landing Zones. In addition, the aircraft's capability to lift cargo/containers from a truck bed directly onboard significantly reduced MHE requirements.

4. The Future Transport Rotorcraft (FTR) is clearly a candidate item. It is obvious that the C-130 and the CH-47 will need replacement. The successor aircraft should not merely be a linear extension of the present capabilities, but rather, should take advantage of technological advances and dramatically different operational requirements to seek solutions for austere entry, air bridge-agile logisitc and ship unloading as examples.

5. Tactical Vehicle Fleet. Our current tactical vehicles do not support Army Transformation. We need tactical vehicles that extend intermodal capability by accommodating containers or container contents with minimum MHE and that have a markedly improved load to weight ratio.

6. Decision Support Tools. Tomorrow's decision support tools should support the tempo and speed of a fluid battlefield and global environment. The commander needs the capability to plan swiftly, evaluate alternatives and "what ifs" quickly, optimize lift selection, track capabilities accurately, and assess the risk of losses.

Carrying Forward the 1999 ASB Recommendations:

The '99 ASB report focused on the end-to-end view of deployment, fully examining the process in a "holistic" way. There were many important initiatives that have been undertaken. There has also been a regular review of progress conducted within the Army Staff to maintain the momentum required to bring these important capabilities to the Army. That process must continue and must ensure that these technology demonstrations reach application in the field.

One is the role of the ISB as a hub. It needs continuing emphasis and further definition. The ISB cannot contribute to improved force closure if it serves only as a relocation site to perform traditional functions outside the theater. The ISB must clearly be part of a complete delivery and distribution system which is dramatically reduced in size and scope from the present structure and requirement.

The use of Controlled Humidity Preservation (CHP) warehouses is another forward-looking proposal of the 1999 ASB report. While the concept forwarded last year was based on an Army National Guard brigade set being positioned in a deployment port, the U.S. Army Reserve has developed a coherent plan to position CS and CSS unit equipment in major port areas to enhance our power projection capability. That program needs to be continued, and similar opportunities need to be sought out.

Work on decision support tools is another area where momentum has to be maintained. The Army has taken very key steps in examining and utilizing the advances offered by DARPA's Advanced Logistics Project (ALP).

The overall emphasis to take full advantage of commercial transportation resources needs to be further developed.

The efforts to reduce the size and weight of future military vehicles have clearly had an impact on the entire R&D community. Focus and discipline have clearly been applied to keep the weight of future vehicles in the 10-20 ton range.

Management of the Program

Providing focus and priority to the R&D program for force projection systems and force projection enablers is not enough. The program needs to be managed at a level that will ensure objectives are achieved and that the fullness of the Objective Force operational concept can be achieved. The agility required to execute the Objective Force concept can be achieved. That force will be pre-disposed through its design to do a wide variety of things on the battlefield, but it will require enablers external to it for true deployment and employment agility. The concepts, doctrine, materiel development and training necessary to provide that agility all need a coordinated and managed effort.

The example of the ASMP as a means to manage and coordinate would serve us well in this new challenge. ASMP identified goals, defined the enablers and provided program management from concept through execution. We need to apply this same process to force projection enablers.

Force projection is essential to the successful transformation of the Army. The whole subject of force projection must infuse everything we do. Force projection must be an operational imperative. Management and direction of force projection must be seen as critically important aspects of the objective force.

The key to assured access for the "last 1000 yards" is a meaningful, focused, and prioritized R&D program. Perhaps that R&D effort would benefit from a new approach.

Much like the Army-DARPA partnership in the Future Combat System (FCS) development, perhaps this R&D effort needs to be outside the bounds of the traditional DOD process. Use of the authority in Title 10 USC, Section 2371 for Other Transactions and 845 Prototype Authorities provides creative and flexible ways to address the problem. Use of this authority has attracted non-traditional technology firms to participate in DOD R&D programs, provides flexibility in today's rapidly changing business environment, and, most importantly, provides the means to acquire cutting edge technology.

The Criticality of Assured Access

Getting the Army's forces effectively into the theater is a critical operational requirement. Much work has been done on the Objective Force, and much more has yet to be done. Assured Access is as central to effective employment as new equipment, radical operational concepts, and dramatically lessened footprint. If the force cannot get to the fight, especially the last 1000 yards, there will be no fight.

TABLE 1

PROJECT	TO BE FIELDED	PUBLICATION	DATE	AGENCY
Heavy Lift Helicopter (22.4 STON)	ASAP	AAR, Evaluation of Off-Shore Discharge of Containterships	Dec-70	USATCFE
Light Weight Top Lifiting Device for Helicopters		AAR, Evaluation of Off-Shore Discharge of Containterships	Dec-70	USATCFE
Mo-Mat performed satisfactorily		OSDOC II Engineering Tests	Mar-72	NCEL
Sea State 3 is probable limit for operation		OSDOC II Engineering Tests	Mar-72	NCEL
Weather and surf conditions separately reported		Preliminary Report, OSDOC II	Nov-72	JANTD
Automated Log Mgmt and Inventory Control System	1975-1982	Army in the Field Container System Study	Sep-74	TRADOC
Air-Land Containers, SAE Aerospace Std 832		Army in the Field Container System Study	Sep-74	TRADOC
Heavy Helicopter Company, 22.5 ton lift	1982	Army in the Field Container System Study	Sep-74	TRADOC
Mobile/Portable Ports		Army in the Field Container System Study	Sep-74	TRADOC
Family of Military Containers		Army in the Field Container System Study	Sep-74	TRADOC
Causeway Ferry/Warping Tug		Self-Powered Causeway System	Oct-75	NCEL
System of Mobile Piers and Causeways		Unloading of Merchant Ships in Contingency Logistics	Nov-76	NAVFAC
Self-Propelled Causeway	FY 81	Container Offloading and Transfer System Pub	Mar-77	NAVFAC
Ro-Ro Interface Eqpt	FY 81	Container Offloading and Transfer System Pub	Mar-77	NAVFAC
Tethered Float Breakwater	FY 81	Container Offloading and Transfer System Pub	Mar-77	NAVFAC
Part of DoD Project Master Plan		A Status Report on the NL Pontoon Elevated Causeway	Apr-77	NCEL
Ctr and Chassis Ident. and Reporting System	Tested 1976	DOD Container Supported Distribution System Master Plan	May-77	OSD
2-Point Cargo Suspension and Slings (CH-53E)	FY 77	DOD Container Supported Distribution System Master Plan	May-77	OSD
Relative Motion Mitigation (cranes)	FY 80	DOD Container Supported Distribution System Master Plan	May-77	OSD
Develop Deployable Breakwaters for Wave Atten.	FY 80	DOD Container Supported Distribution System Master Plan	May-77	OSD
Soil Stabilization, Mo-Mat, AMSS, PSP matting	FY 77	DOD Container Supported Distribution System Master Plan	May-77	OSD
Shore-side Trafficability Surfacing, also in '81		Container System Hardware Status Report	Jul-77	PM-ACODS

PROJECT	TO BE FIELDED	PUBLICATION	DATE	AGENCY
Mobile Port Modules (WES)		Container System Hardware Status Report	Jul-77	PM-ACODS
Barge, Rapidly Deployable (Causeways), also '81	FY 83	Container System Hardware Status Report	Jul-77	PM-ACODS
50,000 Lb. Capacity Sideloader/Trailer, Klaus	Purchased 1972	Container System Hardware Status Report	Jul-77	PM-ACODS
Remote Scanner effective for container tracking		Evaluation of the Army's Capability to Conduct LOTS Opns	Feb-78	ALET
Efforts to dampen sea conditions/breakwater		Report of Lessons Learned, Jt LOTS Test Program	Jun-78	JLTD
Mo-Mat best approach for soil surfacing		Report of Lessons Learned, Jt LOTS Test Program	Jun-78	JLTD
Prestaged Ammunition Loading System		Container System Hardware Status Report	Jan-81	CSDO
Lightweight/Low Volume Container Handler		Container System Hardware Status Report	Jan-81	CSDO
Relative Motion Mitigation (cranes)	FY 83	Container System Hardware Status Report	Jan-81	CSDO
Self-Propelled Causeway	FY 81	Container System Hardware Status Report	Jan-81	CSDO
Ro-Ro Interface Eqpt	FY 85	Container System Hardware Status Report	Jan-81	CSDO
Helicopter Offloading (CH-53E), 16 Tons		Container System Hardware Status Report	Jan-81	CSDO
463L Adapter Pallet for 20 Ft Containers	Tested 1974	Container System Hardware Status Report	Jan-81	CSDO
Unitized loading and unloading of containers		Air Bearing Transporters		NCEL

USATCFE: US Army Transportation Center and Fort Eustis
NCEL: Navy Civil Engineering Laboratory
JANTD: Joint Army Navy Test Directorate
NAVFAC: Naval Facilities Engineering Command
PM-ACODS: Program Manager-Army Container Oriented Distribution System
ALET: Army LOTS Evaluation Team
JLTD: Joint LOTS Test Directorate
CSDO: Containers Systems Development Office

APPENDIX E

DISTRIBUTION

Addressee	Copies
ARMY	
Secretary of the Army, Pentagon, Room 3E700, Washington, DC 20310-0101	1
Under Secretary of the Army, Pentagon, Room 3E732, Washington, DC 20310-0102	1
Deputy Under Secretary of the Army (Operations Research), Pentagon, Room 2E660, Washington, DC 20310-0102	1
Assistant Secretary of the Army (Manpower and Reserve Affairs), Pentagon, Room 2E594, Washington, DC 20310-0111	1
Military Deputy to the ASA(ALT), Pentagon, Room 2E672, Washington, DC 20310-0103	1
Deputy Assistant Secretary for Plans, Programs and Policy, OASA(ALT), Pentagon, Room 3E432, Washington, DC 20310-0103	1
Deputy Assistant Secretary for Procurement, OASA(ALT), Pentagon, Room 2E661, Washington, DC 20310-0103	1
Deputy Assistant Secretary for Research and Technology, OASA(ALT), Pentagon, Room 3E374, Washington, DC 20310-0103	1
Deputy for Systems Management and International Cooperation, OASA(ALT), Pentagon, Room 3E448, Washington, DC 20310-0103	1
Deputy for Ammunition, OASA(ALT), Headquarters, Army Materiel Command, 5001 Eisenhower Ave., Alexandria, VA 22333-0001	1
Deputy for Combat Service Support, OASA(ALT), Headquarters, Army Materiel Command, 5001 Eisenhower Ave., Alexandria, VA 22333-0001	1
Director, Assessment and Evaluation, OASA(ALT), Pentagon, Room 2E673, Washington, DC 20310-0103	1
Director, Army Digitization Office, DACS-ADO, Pentagon, Room 2B679, Washington, DC 20310-0200	1
Director of Information Systems for Command, Control, Communications and Computers, Pentagon, Washington, DC 20310-0107	1
Chief of Public Affairs, Pentagon, Room 2E636, Washington, DC 20310-1500	1
Chief of Staff, Army, Pentagon, Room 3E668, Washington, DC 20310-0200	1
Vice Chief of Staff, Army, Pentagon, Room 3E666, Washington, DC 20310-0200	1
Deputy Chief of Staff for Programs, Army Pentagon, Room 3D652, Washington, DC 20310-0200	1
Director of the Army Staff, Pentagon, Room 3E665, Washington, DC 20310-0200	1
Director, Program Analysis and Evaluation Directorate, Pentagon, Room 3C718, Washington, DC 20310-0200	1
Assistant Chief of Staff for Installation Management and Environment, Pentagon, Room 1E668, Washington, DC 20310-0600	1
Deputy Chief of Staff for Personnel, Pentagon, Room 2E736, Washington, DC 20310-0300	1
Deputy Chief of Staff for Operations and Plans, Pentagon, Room 3E634, Washington, DC 20310-0400	1
Assistant Deputy Chief of Staff for Operations and Plans, Force Development, Pentagon, Room 3A522, Washington, DC 20310-0400	1
Deputy Chief of Staff for Logistics, Pentagon, Room 3E560, Washington, DC 20310-0500	1
Deputy Chief of Staff for Intelligence, Pentagon, Room 2E464, Washington, DC 20310-1000	1
Chief, National Guard Bureau, Pentagon, Room 2E394, Washington, DC 20310-2500	1
Chief, Army Reserve, Pentagon, Room 3E390, Washington, DC 20310-2400	1
Commander, U.S. Army Concepts Analysis Agency, 6001 Goethals Rd., Ft. Belvoir, VA 22060-5230	1
Commander, U.S. Army Evaluation Center, Park Center IV, 4501 Ford Ave., Alexandria, VA 22302-1458	1
Commanding General, U.S. Army Space and Missile Defense Command, P.O. Box 15280, Arlington, VA 22215-0280	1
Chief Scientist, U.S. Army Space and Missile Defense Command, P.O. Box 15280, Arlington, VA 22215-0280	5
Commander, National Ground Intelligence Center, 220 7th St., NE, Charlottesville, VA 22901	1
Director, U.S. Army Research Institute for the Behavioral Sciences, 5001 Eisenhower Ave., Alexandria, VA 22333-5600	1
Commander, U.S. Total Army Personnel Command, Hoffman Building II, 200 Stovall St., Alexandria, VA 22332-0405	1
Commander-in-Chief, U.S. Army Europe and Seventh Army, APO AE 09014	1
Commanding General, Eighth U.S. Army, APO AP 96205	1
Commanding General, U.S. Army South, HQ US Army South, P.O. Box 34000, Ft. Buchanan, Puerto Rico 00934-3400	1

Addressee	Copies
Commanding General, U.S. Army Pacific, Ft. Shafter, HI 96858-5100	1
Commanding General, U.S. Army Forces Command, Ft. McPherson, GA 30330-6000	1
Commanding General, Third United States Army/Army Central Command/Deputy Commanding General, U.S. Army Forces Command, ATTN: AFDC, Ft. McPherson, GA 30330	1
U.S. Army Space Command Forward, ATTN: MOSC-ZC, 1670 N. Newport Rd., Suite 211, Colorado Springs, CO 80916	1
Commanding General, U.S. Army Signal Command, Ft. Huachuca, AZ 85613-5000	1
Commanding General, U.S. Army Special Operations Command, Ft. Bragg, NC 28307-5200	1
Commanding General, U.S. Army Intelligence and Security Command, Ft. Belvoir, VA 22060-5370	1
Commanding General, U.S. Army Medical Command, Ft. Sam Houston, TX 78234	1
Commander, U.S. Army Medical Research and Materiel Command, Ft. Detrick, MD 21702-5012	1
Commanding General, U.S. Army Materiel Command, ATTN: AMCCG, 5001 Eisenhower Ave., Alexandria, VA 22333-0001	1
Commanding General, U.S. Army Materiel Command, ATTN: AMCRDA-TT, 5001 Eisenhower Ave., Alexandria, VA 22333-0001	1
Commander, U.S. Army Chemical and Biological Defense Command, ATTN: AMSCB-CG, Aberdeen Proving Ground, MD 21005-5423	1
Commander, U.S. Army Communications-Electronics Command, ATTN: AMSEL-CG, Ft. Monmouth, NJ 07703-5000	1
Director, Army Systems Engineering Office, ATTN: AMSEL-RD-ASE, Ft. Monmouth, NJ 07703	1
Commander, U.S. Army Aviation and Missile Command, ATTN: AMSMI-CG, Redstone Arsenal, AL 35898	2
Commander, U.S. Army Simulation, Training and Instrumentation Command, ATTN: AMSTI-CG, 12350 Research Parkway, Orlando, FL 32836-3276	1
Commander, U.S. Army Soldier Systems Command, ATTN: AMSSC-CG, Natick, MA 01760-5000	1
Commander, U.S. Army Tank-Automotive and Armaments Command, ATTN: AMSTA-CG, Warren, MI 48397-5000	1
Commander, U.S. Army Test and Evaluation Command, ATTN: AMSTE-CG, Aberdeen Proving Ground, MD 21005-5055	1
Commander, U.S. Army Armament Research, Development and Engineering Center, ATTN: SMCAR-TD, Picatinny Arsenal , NJ 07806-5000	1
Commander, U.S. Army Aviation Research, Development and Engineering Center, ATTN: AMSAT-R-Z, 4300 Goodfellow Blvd., St. Louis, MO 63120-1798	1
Commander, U.S. Army Communications-Electronics Research, Development and Engineering Center, ATTN: AMSEL-RD, Ft. Monmouth, NJ 07703	1
Commander, U.S. Army Missile Research, Development and Engineering Center, ATTN: AMSMI-RD, Redstone Arsenal, AL 35898	1
Commander, U.S. Army Natick Research, Development and Engineering Center, ATTN: SATNC-T, Natick, MA 01760	1
Commander, U.S. Army Tank-Automotive Research, Development and Engineering Center, ATTN: AMSTA-CF, Warren, MI 48397	1
Director, U.S. Army Field Assistance in Science and Technology Activity, 5985 Wilson Rd., Suite 100, Ft. Belvoir, VA 22060-5829	1
Director, U.S. Army Logistics Support Activity, ATTN: AMXLS, Bldg. 5307, Redstone Arsenal, AL 35898-7466	1
Director, U.S. Army Materiel Systems Analysis Activity, ATTN: AMXSY-D, Aberdeen Proving Ground, MD 21005-5071	1
Director, U.S. Army Research Laboratory, ATTN: AMSRL-D, 2800 Powder Mill Rd., Adelphi, MD 20783-1145	1
Director, U.S. Army Research Office, ATTN: AMXRO-D, P.O. Box 12211, Research Triangle Park, NC 27709-2211	1
Commanding General, U.S. Army Training and Doctrine Command, Ft. Monroe, VA 23651-5000	1
Deputy Commanding General, U.S. Army Training and Doctrine Command, Ft. Monroe, VA 23651-5000	1
Deputy Commanding General, U.S. Army Training and Doctrine Command for Combined Arms/Commander, U.S. Army Combined Arms Center/Commandant, Command and General Staff College, Ft. Leavenworth, KS 66027-5000	1
Deputy Commanding General, U.S. Army Training and Doctrine Command for Combined Arms Support/	

Addressee	Copies
Commander, U.S. Army Combined Arms Support Command and Ft. Lee, Ft. Lee, VA 23801-6000	1
Commander, U.S. Army Aviation Center and Ft. Rucker/Commandant, U.S. Army Aviation School/Commandant, U.S. Army Aviation Logistics School (Ft. Eustis), Ft. Rucker, AL 36362-5000	1
Commander, U.S. Army Signal Center and Ft. Gordon/Commandant, U.S. Army Signal School, Ft. Gordon, GA 30905-5000	1
Commandant, U.S. Army War College, ATTN: AWCC-CSL-OG, 122 Forbes Avenue, Carlisle Barracks, PA 17013-5050	1
Commander, U.S. Army Air Defense Artillery Center and Ft. Bliss/Commandant, U.S. Army Air Defense Artillery School, Ft. Bliss, TX 79916-5000	1
Commander, U.S. Army John F. Kennedy Special Warfare Center and School, Ft. Bragg, NC 28307-5000	1
Commander, U.S. Army Quartermaster Center and School/Deputy Commander, U.S. Army Combined Arms Support Command and Ft. Lee/Commandant, U.S. Army Quartermaster School, Ft. Lee, VA 23801-6000	1
Commander, U.S. Army Infantry Center and Ft. Benning/Commandant, U.S. Army Infantry School, Ft. Benning, GA 31905-5000	1
Commander, U.S. Army Ordnance Center/Commandant, U.S. Army Ordnance School, Aberdeen Proving Ground, MD 21005-5201	1
Commander, U.S. Army Field Artillery Center and Ft. Sill/Commandant, U.S. Army Field Artillery School, Ft. Sill, OK 73503-5000	1
Commander, U.S. Army Transportation Center and Ft. Eustis/Commandant, U.S. Army Transportation School, Ft. Eustis, VA 23604-5000	1
Commander, U.S. Army Armor Center and Ft. Knox/Commandant, U.S. Army Armor School, Ft. Knox, KY 40121-5000	1
Commander, U.S. Army Intelligence Center and Ft. Huachuca/Commandant, U.S. Army Intelligence School, Ft. Huachuca, AZ 85613-6000	1
Commandant, U.S. Army Ordnance Missile and Munitions Center and School, Redstone Arsenal, AL 35897-6000	1
Commandant, Army Logistics Management College, Ft. Lee, VA 23801-6053	1
Director, U.S. Army Training and Doctrine Command Analysis Center, Ft. Leavenworth, KS 66027-5200	1
Commander, Battle Command Battle Lab, ATTN: ATZL-CDB, 415 Sherman Ave., Ft. Leavenworth, KS 66027-5300	1
Commander, Battle Command Battle Lab, ATTN: ATZH-BL, Ft. Gordon, GA 30905-5299	1
Commander, Battle Command Battle Lab, ATTN: ATZS-BL, Ft. Huachuca, AZ 85613-6000	1
Commander, Combat Service Support Battle Lab, ATTN: ATCL-B, Ft. Lee, VA 23801-6000	1
Commandant, Depth and Simultaneous Attack Battle Lab, ATTN: ATSF-CBL, Ft. Sill, OK 73503-5600	1
Commandant, Dismounted Battle Space Battle Lab, ATTN: ATSH-WC, Ft. Benning, GA 31905-5007	1
Commander, Early Entry Lethality and Survivability Battle Lab, ATTN: ATCD-L, Ft. Monroe, VA 23651-5000	1
Commander, Mounted Battle Space Battle Lab, ATTN: ATZK-MW, Ft. Knox, KY 40121-5000	1
Commander, Battle Lab Integration, Technology and Concepts Directorate, ATTN: ATCD-B, Ft. Monroe, VA 23651-5000	1
Program Executive Officer, Armored Systems Modernization, ATTN: SFAE-ASM, Warren, MI 48397-5000	1
Program Executive Officer, Aviation, ATTN: SFAE-AV, 4300 Goodfellow Blvd., St. Louis, MO 63120-1798	1
Program Executive Officer, Command, Control and Communications Systems, ATTN: SFAE-C3S, Ft. Monmouth, NJ 07703-5000	1
Program Executive Officer, Field Artillery Systems, ATTN: SFAE-FAS, Picatinny Arsenal, NJ 07806-5000	1
Program Executive Officer, Intelligence and Electronic Warfare, ATTN: SFAE-IEW, Ft. Monmouth, NJ 07703-5000	1
Program Executive Officer, Missile Defense, ATTN: SFAE-MD, P.O. Box 16686, Arlington, VA 22215-1686	1
Program Executive Officer, Standard Army Management Information Systems, ATTN: SFAE-PS, 9350 Hall Rd., Suite 142, Ft. Belvoir, VA 22060-5526	1
Program Executive Officer, Tactical Missiles, ATTN: SFAE-MSL, Redstone Arsenal, AL 35898-8000	1
Program Executive Officer, Tactical Wheeled Vehicles, ATTN: SFAE-TWV, Warren, MI 48397-5000	1
Program Executive Officer, Cruise Missiles Project and Unmanned Aerial Vehicles Joint Project, ATTN: PEO-CU, 47123 Buse Rd., Unit 1PT, Patuxent River, MD 20670-1547	1
Program Executive Officer, Combat Support Systems, ATTN: AF PEO CB, 1090 Air Force Pentagon, Washington, DC 20330-1090	1
Superintendent, U.S. Army Military Academy, West Point, NY 10996	1
NAVY	
Secretary of the Navy, Pentagon, Room 4E686, Washington, DC 20350	1
Under Secretary of the Navy, Pentagon, Room 4E714, Washington, DC 20350	1

Addressee	Copies
Assistant Secretary of the Navy (Research, Development and Acquisition), Pentagon, Room 4E732, Washington, DC 20350	1
Chief of Naval Operations, Pentagon, Room 4E674, Washington, DC 20350	1
Vice Chief of Naval Operations, Pentagon, Room 4E636, Washington, DC 20350	1
Commandant, U.S. Marine Corps, Pentagon, Room 4E714, Washington, DC 20380	1
Naval Research Advisory Committee, 800 N. Quincy Street, Arlington, VA 22217-5660	1
President, Naval War College, Code 00, 686 Cushing Rd., Newport, RI 02841-1207	1
AIR FORCE	
Secretary of the Air Force, Pentagon, Room 4E871, Washington, DC 20330	1
Under Secretary of the Air Force, Pentagon, Room 4E886, Washington, DC 20330	1
Assistant Secretary of the Air Force (Acquisition), ATTN: SAF/AQ, Pentagon, Room 4E964, Washington, DC 20330	1
Chief of Staff, United States Air Force, Pentagon, Room 4E924, Washington, DC 20330	1
Vice Chief of Staff, United States Air Force, Pentagon, Room 4E936, Washington, DC 20330	1
Air Force Scientific Advisory Board, Pentagon, Room 5D982, Washington, DC 20330	1
President, Air War College, 325 Chennault Circle, Maxwell Air Force Base, AL 36112-6427	1
OSD	
Secretary of Defense, Pentagon, Room 3E880, Washington, DC 20301	1
Deputy Secretary of Defense, Pentagon, Room 3E944, Washington, DC 20301	1
Under Secretary of Defense for Acquisition and Technology, Pentagon, Room 3E933, Washington, DC 20301	1
Under Secretary of Defense (Personnel and Readiness), Pentagon, Room 3E764, Washington, DC 20301	1
Assistant Secretary of Defense (Command, Control, Communications and Intelligence), Pentagon, Room 3E172, Washington, DC 20301	1
Deputy Under Secretary of Defense for Advanced Technology, Pentagon, Room 3E1045, Washington, DC 20301	1
Deputy Under Secretary of Defense for Environmental Security, Pentagon, Room 3E792, Washington, DC 20301	1
Principal Deputy Under Secretary of Defense for Acquisition and Technology, Pentagon, Room 3E1006, Washington, DC 20301	1
Chairman, Joint Chiefs of Staff, Pentagon, Room 2E872, Washington, DC 20318-9999	1
Vice Chairman, Joint Chiefs of Staff, Pentagon, Room 2E860, Washington, DC 20318-9999	1
Director, Defense Research and Engineering, Pentagon, Room 3E1014, Washington, DC 20301-3030	1
Director, Defense Advanced Research Projects Agency, 3701 N. Fairfax Dr., Arlington, VA 22203-1714	1
Director, Defense Information Systems Agency, 701 S. Courthouse Rd., Arlington, VA 22204-2199	1
Director, Defense Logistics Agency, 8725 John J. Kingman Rd., Suite 2533, Ft. Belvoir, VA 22060-6221	1
Director, National Imagery and Mapping Agency, 4600 Sangamore Road, Bethesda, MD 20816-5003	1
Defense Science Board, Pentagon, Room 3D865, Washington, DC 20301	1
Commandant, Defense Systems Management College, 9820 Belvoir Rd., Suite G-38, Ft. Belvoir, VA 22060-5565	1
President, National Defense University, 300 5th Avenue, Ft. McNair, Washington, DC 20319-5066	1
Commandant, Armed Forces Staff College, 7800 Hampton Blvd., Norfolk, VA 23511-1702	1
Commandant, Industrial College of the Armed Forces, 408 4th Ave., Bldg. 59, Ft. McNair, Washington, DC 20319-5062	1
Commandant, National War College, Washington, DC 20319-5066	1
National Security Space Architect, 2461 Eisenhower Avenue., Suite 164, Alexandria, VA 22331-0900	1
OTHER	
Defense Technical Information Center, ATTN: DTIC-OCP, 8725 John J. Kingman Rd., Suite 0944, Ft. Belvoir, VA 22060-6218	1
National Research Council, Division of Military Science and Technology, Harris Bldg Rm. 258, 2101 Constitution Avenue NW, Washington DC 20418	1
Director, Institute for Defense Analyses, ATTN: TISO, 1801 N. Beauregard St., Alexandria, VA 22311-1772	1
Library of Congress, Exchange and Gift Division, Federal Document Section, Federal Advisory Committee Desk, Washington, DC 20540	1